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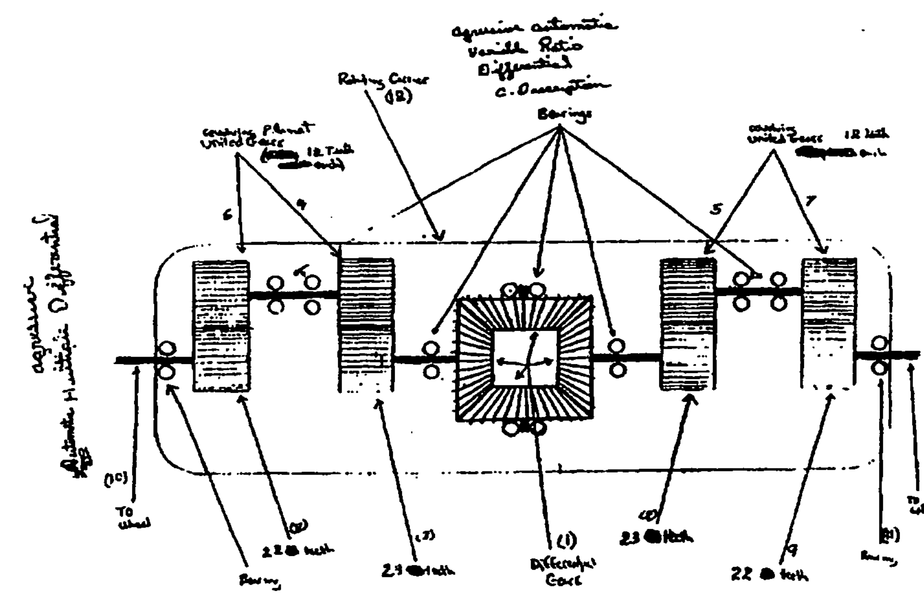

(57) Abstract

Torque sensing, speed sensing, horse power sensitive differential gear system which uses a true mechanical ratio instead of mechanical friction to proportion torque between vehicle wheels. The torque is divided amoung the drive wheels in proportion to need and efficacy.

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Section One

Automatic Variable Ratio Differentials (AVRD)

A group of Unique torque-sensing and speed sensing (horsepower sensitive) differentials which use a true mechanical ratio instead of mechanical friction to proportion torque between vehicle wheels.

Inventors Overview and summary——Bill Rogers

A. The first purpose of a rotary prime mover is to rotate a drive chain, which does not necessarily produce the desired purpose.

B. The desired purpose is to impart linear or curvilinear motion to a vehicle across terrain.

C. In the Automatic Variable Ratio Differential, an additional set of cooperative true mechanical ratios are introduced to the rotary drive chain which improves the transfer of power from rotary to linear and curvilinear paths of motion which are the desired outlet. This is accomplished by dividing the torque among the drive wheels in predetermined proportion (True Mechanical Ratio) to need and efficacy. It is possible to custom vary the proportion in terms of variable gear ratios which have exactly definable equations throughout their range. It is therefore unnecessary to use slip clutches or inefficient gears or gear arrangements which waste power, create heat and wear out prematurely.

D. In a vehicle which is going straight ahead, the differential gears throughout an assembly should not be rotating in relation to each other.

The automatic transition (phase shift See NOTE 10) of our device from a system of simple reducers incapable of running in two gears (two inputs) at once, which pull straight ahead in lock-step with a (constant) ground-link, to a cooperative system of simple and fixed/differential ratios which assume complex internal motion with variable, true mechanical ratio, torque proportioning (biasing) qualities capable of curvilinear motivation and automatic torque proportioning (biasing) response to road conditions, turns, and loss of traction (variable ground-link).

In straight forward mode the ground link, and the fixed differentials cooperate with the open differential and make the axle unitary in character, in a curve the axle divides up into three sets of interactive (variable) ratios and proportions torque between the wheels. In a bog, the axle divides up into three sets of interactive (variable) ratios to place a mechanical advantage to the wheel with traction. All this occurs in a completely cooperative relationship with analog characteristics that proportion the torque to the wheel with traction.

Ratio #1 is in the center differential which varies from 1:2 OD to 1:1

Ratio # 2 and #3 are in the two fixed differentials which, in prototype, vary from 24:1 to 1:1 but can be custom configured to vehicle needs.

Therefore we have created a Unique torque sensing and speed sensing differential which uses a true mechanical ratio instead of mechanical friction to proportion torque. In these devices any output can assume most of the speed and/or torque of the differential carrier.

These are basic patentable principals of the Automatic Variable Ratio Differential.

E. Transition (phase shift) to both simple and compound ratios (based on Fixed differential epicycles and hypocycles (See NOTE 10 B&C), the ratio of which are created by relatively similar size gears working off differences in number of teeth see Section 1 AA & Section 3 B .) operating together to create a linear outlet in straight-aways or create two curvilinear outlets in a turn with torque equalization, or transition (phase shift) to one slower outlet with a Torque Proportioned Ratio and one faster outlet with a Torque Proportioned Ratio when one axle rotates faster or slower than the other as in a bog or a turn. In an instance when a wheel loses traction any resistance given to the free-spinning side helps bring the planet pinion input (fixed-differential epicycle) into play and ratio variation begins to apportion torque to the wheel with traction.

The effect of the Automatic Variable Ratio Differential is to create (2-4 or multi-wheel drives) wherein each wheel is capable of automatic synergetic shifts to proportion the torque. Each axle becomes capable of variable ratios which specifically send torque to the axle with traction, because the system has analog qualities which perform automatic analysis of speed and torque by comparisons of the numerical variables in the True Mechanical Ratio of the setup. The fixed differentials can be added to any standard (open) differential, or limited slip differential (LSD such as Torsen, Quaife, Sierra etc.) to improve performance. Therefore any place the terms standard (open) differential appear all of these may be assumed to be compatible.

The AVRD is a passive device (no control system required) or it may be used with Traction Control Systems. In general Limited Slip Differentials are passive devices which proportion torque through the generation of an axle torque difference. Types of LSD's are presently: Torque Sensing and Speed Sensing. Torque sensing differentials make use of Mechanical Friction, and Speed sensing differentials require development of wheel speed difference in order to actuate.

The True Mechanical Ratio Variations of the AVRD, and its resulting personality, make it both Torque Sensing and/or Speed Sensing throughout its operating range and the two senses are synergetic.

Equal facial pressure and balance on the bevel gears of the open differential operating alone is a redundant statement. However, in the aggressive AVRD, pressure is upset and balance is lost when the fixed differential (remember this 22:1 reducer runs its bevel gear in the same direction as carrier rotation or slows its axle) comes into play. Because the 2:1 overdrive of the open differential immediately reacts to regain balance at a ratio as close to 1:1 in a bog or to that proper to the radius of a turn in execution or factors of both.

When an axle tries to spin its fixed differential either reduces its speed and/or feeds speed to the axle with greater traction because the 2:1 overdrive in the open differential jumps into the equation.

If the spinning axle slows 1 RPM, the overdrive sends 2 RPM to the slower side bevel gear. The difference in the spinning axle speed and the axle with traction bevel gear speed is a 3:1 ratio correction, which is (3x22) 66 times as fast a correction as the (22 : 1) ratio which caused the system imbalance. During this process the 22:1 reducer varies up toward 1:1 and the 2:1 overdrive varies down toward 1:1.

In the AVRD a wheel which loses part of its traction actually becomes the place upon which the system pushes to add torque to the wheel with traction and regain forward motion. This is made possible by the ratio phase shifts which occur.

There are 6 sets of variable ratios in the aggressive AVRD (counting the two simple ratios which are close to 1:1 being 22:23 and 23:22) this explanation takes into account 4 sets of variable ratios, all 6 are cooperative (synergistic) and the 2:1 overdrive in the open differential is by far the faster of the lot. This 2:1 overdrive ratio is very important because large variations of wheel torque can be dealt with at full operating speed, by the analog quality of the system, using very small variations of wheel (tire) rim speed as an indicator of the need for the ratios to respond to each other in terms of speed and torque. In other words very little ground slippage will take place and that which does will be spread over some distance, since the vehicle will seldom quit moving.

Currently a positive traction rear end is a solid driving axle with no effective differential. In such a device the two wheels do not respond to each other through the ground link either in a turn or a bog.

The AVRD is a more than true positive traction because it allows the tires to respond to each other in terms of torque and speed and yet allows no slippage (true positive traction) in the vehicle rear end. <u>(The AVRD is POSITIVELY TRACTION)</u>

The aggressive and the creeping AVRD operate toward the same purpose but each explanation differs in terms of ratio configuration. (See larger text)

Bill Rogers 9/15/97

Addendum to Inventors overview
Automatic Variable Ratio Differentials (AVRD)

Inventors Overview and summary——Bill Rogers
11/17/97 – Revised 1/24/98

Further study of the device described in our earlier text have led to these conclusions and additions:
All conclusions of operation of fixed differentials include planetary set configurations described later in the text. The creeping AVRD made with fixed differentials is the most easily demonstrated of the forward devices. The reversing devices (Drawings 9B, C & D) Photo #9C&D created using planetary sets are equally dramatic on video or in person since they have both all the AVRD qualities and reversing capability both automatic in conjunction with a steering axle ground link and controlled by a brake on the planetary carrier. This paper should be considered cumulative in its' conclusions.

Newtons' third law of motion (For each action there is an equal and opposite reaction) goes on continuously as the two fixed differentials look at each other through the open differential and react to each other in looking glass fashion.

The power train of the AVRD pushes off the carrier, therefore it cannot develop more torque than is available to the carrier and neither can the sum of the wheel speeds be greater than twice the carrier speed. Therefore, as the largest ratio (24:1) begins to transfer torque near the carrier torque potential the device switches to speed sensing, and varies its effective ratio in proportion to torque. This slows the spinning wheel even as the wheel with traction receives horsepower from the system (Speed and torque being the components of horsepower, the device is horsepower sensitive.)

Speed sense + Torque sense = Horsepower sense

This circulating horsepower constantly seeks the path of least resistance:

The instant the planets begin to orbit = the instant of slip = The instant of 2 adjustments

Therefore the variable ratio causes the system to search the following alternates for the path of least resistance:

1. **Stall the engine = Sufficient power sends the search elsewhere.**
2. **Wheel spin = Secondary ratio of the AVRD takes over as the planet gears begin to orbit the slower moving axle.**
3. **A new path of least resistance is created directing power to the wheel with traction.**
4. **The wheel with traction begins to pull with multiples of the traction of the spinning wheel, ratio variation searches for the highest ratio which will break inertia and produce forward motion and not exceed carrier torque or speed.**

5. When traction is greater than inertia = The final path of least resistance is forward motion of the vehicle.
6. The vehicle assumes an attitude better than positive traction, it positively seeks maximum efficacit traction. (Positively Traction)
7. These steps = Full time positive horsepower distribution as the ground link is able to accept the force. POSITIVELY TRACTION

Example:

When the force needed to move a vehicle is 300 lb. of forward thrust.
When the carrier RPM is 100
The spinning wheel encounters 30 lb. of traction
The wheel with traction will seek a ratio of 9 : 1 and multiply the 30 times 9 = 270 lb.
30 + 270 = 300 = The vehicle begins to move forward.

The variable ratio begins to search for that ratio which will gain speed at the tire with most traction in proportion to the horsepower available at the carrier without exceeding the speed or torque available to the carrier.

If the traction of the slipping wheel varies plus or minus, the ratio of the AVRD varies in proportion or changes from wheel to wheel as ground link conditions vary. Therefore, the vehicle maintains forward motion (desired motion). Since this process is on going at all speeds, and varies up the ratio scale as well as down, it operates in unison with vehicle forward motion(inertia), the traction and vehicle inertia is maintained by constant, instantaneous, and minute adjustment of horsepower distribution. This process is less likely or unlikely to let the vehicle become immobile or do damage to the ground link conditions which are of obvious value to passage of the individual vehicle, the next vehicle or the return trip conditions which face the individual vehicle or convoy.

These steps are for the drive train, much the same as Anti-lock Brake Systems are for stopping a car and may work similarly when a vehicle uses the drive chain as the braking system of a vehicle on a protracted, steep downhill slope or aid safety in ordinary slowing to a stop. The variable nature of the device also acts as a buffer to absorb torque shock in the drive train both from the engine and from road conditions. It may therefore be possible to down size the power train. This trait will make the effective cost of the device negative. Also, the AVRD will reduce torque steer in front wheel drive vehicles, which is a problem upon accelerate from stop. The tendency of the variable ratio to spread torque shock over time will reduce axle breakage.

Random Thoughts

There are several versions of the device which answer as Automatic Variable Ratio Transmissions AVRT:

1. Any version discussed in this text.
2. Any combination or mix of devices, fixed differential, planetary sets and etc.:

b. For the purpose of this paper planetary sets are like Drawing 10 and described in the text of Drawing 11A & 11B.

A. An aggressive side and a creeping side on the same device will create a transmission with a biased or weighted output. (A bias to speed and/or a bias to torque.)

The Infinitely Variable Transmission will be a biased differential, using configurations different on each side, even the idler gear type which will make it easy on a brake while it also helps store power in a flywheel. The looking glass becomes weighted but not distorted. The reversing AVRD has been observed to have three forwards and one reverse on each axle.

B. A third type device I call Super Aggressive is created by adding an idler to the fixed differential (as in section three) works in any combination or at both sides of a differential. Photo # 8

C. Any inefficiency of the device can be used to an advantage when torque is low on the slipping wheel thus certain applications may choose to make combinations with existing limited slip differentials.

D. When the AVRD is used as a automobile type differential with a ground link, it assumes five (5) inputs and two (2) outputs. 3 inputs at the differential carrier, 2 back feed inputs from the wheels, 2 outputs at the wheels all of these alternate with changing road conditions.

3. A description of the shorter turning radius device:

A. A very slow creep device (high ratio in the side differential) will cause the inside wheel to move very slow in a turn thus producing a tighter turning radius.

B. An X-Super Aggressive (created by using an idler gear in the side differential, or other method) will also cause the inside wheel to slow, stop, or reverse thus reducing the vehicle turning radius.

4. Description of Torque Shock Absorption

A. The tendency of the device to absorb torque in the form of ratio variation will greatly reduce torque shock throughout the drive system. Since this factor accounts for much of the need for strength in the drive train parts (size and weight). It may be possible to down size the drive system and/or the vehicle. This feature is the same as one of the main functions of a torque converter in or clutch in a drive train, to absorb road shock etc.

B. Ratio Variation at all speeds is ~~quick~~ because of the 2:1 OD in the open differential.

5. The device will help tire wear rubber pollution by sending torque where it can best be used. Torque compensation at the differential before slippage of a tire occurs reduces tire wear. Right spin is balanced by a left side orbit of compensation and vice versa.

B. Rogers 12/8/97

This device will do for torque shock in the drive train of a vehicle, the same thing as a pneumatic tire has done for the wheel. 12/17/97

— Hand written.

Descriptions of a (A) standard (Open) differential
and a (AA) fixed differential which combine to form:

(B) Creeping or (C) Aggressive
With External Gearing
(D) & (E) Creeping or Aggressive using Annular Gears, (EE) Planetary Set Differentials With Annular Gearing (F) Infinitely Variable Drive (G) AVRD Using Idler Gears
(Automatic Variable Ratio Differentials)

A group of Unique torque sensing and speed sensing (horsepower sensitive) differentials which use a true mechanical ratio instead of mechanical friction to proportion torque between vehicle wheels.

6/28/97

Reference Disclosure Document # 379469 April 3, 1996

Note: It can be assumed all primary inputs are through an attachment to the standard (open) differential such as a ring gear or pulley.

A. Explanation of a standard (open) differential

(Center of Automatic Variable Ratio Differential—One Used)

A Differential gear system divides the torque of a rotational prime mover between the axle shafts of a vehicle and allows them to rotate at different speeds when turning corners.

Each differential side gear is splined to an axle shaft. The pinion gears are mounted on a mate shaft and are free to rotate on the shaft. The pinion gear is fitted to a bore in the differential case and is positioned at a right angle to the axle shafts. Drawing 1 Fig. 1

In operation, power flow occurs as follows: The propeller shaft pinion gear rotates the ring gear. The ring gear, which is bolted to the differential case, rotates the case. The differential pinion gears , which are mounted on the pinion mate shaft, which is fitted to the case, rotate the side (bevel) gears. The side (bevel) gears, which are connected to the axle shafts, rotate the shafts.

During straight-ahead driving, The differential pinion gears do not rotate on the pinion mate shaft. This occurs because input torque applied to the gears is divided and distributed equally between the two side (bevel) gears. As a result, the pinion gears revolve with the pinion mate shaft but do not rotate around it. — Drawing 1 Fig. 1 see arrows pinion (As we shall see later. In the AVRD this fact operates cooperatively with the planet gears of the two fixed differentials or planetary sets, which also cease revolving, to make the axle between a pair of wheels unitary when straight ahead motion is required of an AVRD equipped vehicle. This is of absolute importance.)

When turning corners, the outside wheel must travel a greater distance than the inside wheel in order to complete the turn. This difference must be compensated for in order to prevent the wheels from scuffing and sliding through the turn. To accomplish this, the differential becomes effective allowing the axle shafts to rotate at different speeds. Drawing 1--Figure 2 (It is important to note: The carrier rotates at a third speed, constant with the prime mover, faster than the inside output, slower than the outside output.) In this instance, the input torque applied to the pinion gears is not divided equally. (It is important however, to remember: The facial pressure applied to the two side (bevel) gears remains equal) The pinion gears now rotate around the pinion mate shaft attached to the outside wheel side (bevel) gear to rotate the outside wheel at a faster speed. Drawing 1 Fig. 2 see arrows

In such standard differentials torque transmitted to each axle shaft is equal at all times. However, if one wheel slips, the opposite wheel will generate only as much torque as the slipping wheel. If the total forward thrust of the two is less than the inertia or other resistance to linear motion of a vehicle the entire machine becomes helpless. The following descriptions are of devices to solve this and other torque problems.

NOTE: Any AVRD will operate and function well with any differential regardless of the ration in the open differential. 2:1 or more or 2:1 or less.

AA. FIXED DIFFERENTIAL—High Ratio

(Side Sectors of an Automatic Variable Ratio Differential—Two Used)

BASIC PRINCIPAL :

1. A rotating carrier (drum, pulley, etc.) on bearings. Drawing #5 Item 1-Engineers Fig.2 Item 12
2. An orbital shaft on bearings with two gears affixed. Drawing #5 Item 2-Engineers Fig.2 Item 12
3. Two gears, on bearings at the axis of the carrier, and in mesh with the orbital gears mounted on the output shafts. Drawing #5 Items 3 & 4-Engineers Fig. 2 Item 11
4. Braking or locking devices capable of forcing either of the sun gears to stand still and become a reactionary gear. This restraining device can be a second rotational input a set up which creates variable ratios (Phase Shifting). Drawing #5 Items 5 & 6, Photo #2, Engineers Fig. 2

(Phase Shifting occurs when the fixed member of the fixed differential is given a rotation of its own. This rotation directly effects output speed and path of torque in our device)

5. A difference in the number of teeth in the sun gears of the fixed differential, and/or a difference in the number of teeth in the orbital gears or a combination of both.

Example:

One sun gear has 24 teeth at one end. The opposite sun gear has 23 teeth on its end The pairs of orbital gears have 12 teeth each . Drawing #5 Items 7 & 8-Engineers Fig. 2 Item 9&10

Results of the preceding facts:

Description of an output on the larger sun gear side.

6. The 23 tooth gear is restrained.
7. The orbital gears are placed in motion by rotating the carrier to which their bearings are affixed.
8. As the orbital gear rotates about the 23 tooth reactionary sun gear, a relationship is set up with the opposite (output) sun gear which has 24 teeth.
9. This relationship is equal to the product of 24/23 = 1 remainder. The one tooth falls back and pulls the 24 tooth gear in the same direction as the carrier and its own rotation. This produces a reduction of 24:1 ratio with output in the same direction as the carrier.

(Phase Shifting by a second rotational input instead of a static restraint adds an effect like a third dimension to the motions here described and creates the variable ratios necessary to the Automatic Variable Ratio Differential described later.)

Description of an output on the smaller sun gear side.

10. The 24 tooth gear is restrained.
11. The orbital gears are placed in motion by rotating the carrier to which their bearings are affixed.
12. As the orbital gear rotates about the 24 tooth reactionary sun gear, a relationship is set up with the opposite (output) sun gear which has 23 teeth.
13. This relationship is equal to the quotients remainder of 24/23= 1 remainder. The one tooth carries forward and pushes the 23 tooth gear in the opposite direction as the carrier rotation. This produces a reduction of 23 : 1 ratio with output in the opposite direction as the carrier.

There are 4 variables in this formula. Any variation of relationship in # of teeth changes the ratio. When several variables come into play, the ratio assumes a factor equal to the aggregate remainder of the difference of the sets of orbitors in motion and the quiescent member, divided into the last member in motion. The result is a forward motion of the output shaft when the aggregate is a negative number, reverse when the aggregate is positive, and zero motion when the aggregate is in balance.

14. The device can be made with spur gears, herring bone gears, helical gears, (Drawing 2&5) annulus gears, (Drawing 3) (Annulus Gears can be used inside each other in multiple layers to produce very high reductions) A carrier is described as any make up, which will rotate the satellite device through the mesh of the sun gears in the manner required.
15. Differences between Metric and Avoirdupois gear sizes can be exploited to create reductions, with off- the- shelf size gears and sprockets.
16. Pinion, helical, and herring bone gears can operate within annulus gears to create tremendous reduction, and very high contact ratio in a very small unit to torque ratio.
17. Reduction back through when one output is turned with the carrier held immobile is not as great as the reduction created by rotating the carrier and restraining an output. Another result is to say, the reduction or overdrive produced by turning an output shaft with the carrier locked, is of the simple variety when it comes out at the other output, but locking an output and driving the other output will cause a high speed overdrive of the carrier.
18. Extreme reductions can be generated by using a different diametrical pitch gear at the two ends as a way to vary the size, tooth, reduction relationship of the unit.(Also Metric to Avoirdupois) By this method gears of exactly the same outside diameter can produce ratios because their pitch diameter is different.

(Phase Shifting occurs when the fixed member of the group is given a rotation of its own. This rotation directly effects output speed and path of torque in our device)

19. Fast forward or reverse or slow motion or stop and go, control is made possible by the ability to drive from more than one place at once (Phase Shifting). The shaft in motion is a slave of the reactionary shaft and its gear.
20. A fixed differential may be any of those described or mentioned in Dudley's Gear Handbook--All epicycles and hypocycles of chapter 3— fig. 3.12, 3.13, 3.14 & 3.24 etc. or similar publications describing devices of like characteristics. Dudley's Gear Handbook--Table 3.9 Pg 3.29 covers fixed differential gear data ratio formulas.
21. These facts bring us to the point of this paper:

When a Standard (open) Differential is combined with two Fixed Differentials or other Planetary Sets the system acquires the ability of a stopped wheel to Creep or have an Aggressive forward as determined by configuration. Drawing 4A&B, 6, 7, 9ABC&D, & 12 - Photo 3AB, 4AB, 5AB, 7, 8, & 9ACD

These devices especially (Photo 1, & 9ABCD – Drawing 9ABC & D) can be configured to have an ability of the stopped wheel to reverse which reduces the turning circle of a vehicle. A fork-lift can make a facing movement.

We will now describe several Synergistic variations of this combination

Automatic Variable Ratio Differentials

Note # of teeth configuration is custom for any gear of Drawing 2, 3, 4A&B, 5, 6, 7, 9ABC&D, &12 or Photo # 1, 2, 3A&B, 4A&B, 5A&B , 6AB, 9AC&D, & 12 values are assigned for convenience, however, small variations anywhere in the system make drastic

changes in the personality of the device.

AAA. Planetary Sets (Low Ratio Fixed Differential) are described in Drawing 11A & 11B and reduced to practice in an AVRD in Drawing 9ABC&D&12 and Photo #9AC&D. Here Planetary Sets are used as a form of Fixed differential since one of the members is attached to the planetary carrier and remains fixed in reference to the differential in the middle.

B. Explanation of a "Creeping" differential

An Automatic Variable Ratio Differential with the spur gear affixed to each side (bevel) gear being the smaller. Drawing 6 & 4A Items 2&3 – Photo # 3 A&B Items 2&3

A power train assembled with a rotational prime mover acting through a spider gear, spur gear or other standard (open) differential of the types used in rolling stock and road vehicles, created to function as described above in explanation A. (All differentials perform the same task regardless of configuration.) Drawings 1 Fig. 1 & 2 - Photo #6A Engineers Drawings Fig. 1,2 & 3

The two outputs of a Standard (open) differential are affixed to a spur (sun) or annular gear of the same diameters and numbers of teeth. Drawing 4A & 6 Photo 3A&B Items 2 & 3 These two gears are set facially adjacent to a pair of spur (sun or annular) gears Drawing 4A & 6 Item 8 & 9 (attached to the final drives or axles.) which have more teeth (or differ in tooth form so as the pitch diameters are larger even if the outside diameters are equal) than the gears (Drawing 4A & 6–Photo 3A&B Items 8 & 9) (or differ in tooth form so as the pitch diameters are different even if the outside diameters are equal) mounted at the end of the outputs of the standard differential. (This set up tends to create ratio variation in the system .) These rotations are second inputs as described in -- Section 1 AA -- and produce Phase Shifts within the system. All of the feedback and primary inputs are an aggregate which create the variable ratio.

Planetary to the pairs of sun gears set up on each side of the differential, and attached to rotate with the carrier yet free to revolve about their own center or shaft, are pairs (or a plurality of pairs) of planet gears Drawing 4A& 6 Photo 3A&B Items 6/4 & 5/7 each pair made as one (Planets) and fitted to the sun gears in a way which creates a rotational attachment between them, and to an axle or other final drive. Such attachment and variation of size or form creates a reduction as described by the fixed differential method and formulas. (See Section 1 AA.) Also there are second rotational inputs which vary the ratio (Phase Shift) of the effected differential (See Section 1 AA and NOTE 10).

The outputs of such fixed differentials rotate in the same direction as the carrier (Drawing 2&5 Right Side) and counter to the carrier (Drawing 2 & 5 Left Side) with a ratio created by a small difference in number of teeth. When two such devices are set up to oppose each other through a standard (open) differential as described (Drawing 6) and above they compliment the open differential and form the Creeping Automatic Variable Ratio Differential.

The said planet gears Drawing 4A& 6 Photo 3A&B Items 6/4 & 5/7 physically attach the two suns on each side and make whole two axles or final drives. In a vehicle the ground completes the system. The ground-link torque and system union of the vehicle drive can lose definition when a wheel slips. In a current spider gear differential used alone this can cripple a vehicle, because when one wheel slips, the opposite wheel will generate only as much torque as the slipping wheel. If the force generated by the two is not equal to that necessary to move the vehicle it will remain immobile. The creeping differential's variable ratios (fixed differentials) re proportion the system (by Phase Shifts) when a wheel slips directing Multiplied torque to the wheel with traction and the vehicle becomes mobile again. One wheel can therefore assume most of the speed and torque of the differential carrier. (See part D. of the abstract)

In the Creeping Automatic Variable Ratio Differential (Drawing 3A& 6 Photo 3A&B) an additional link is created by the fixed differentials (Drawing3A& 6Photo3A&B Items 6/4/8/3 & 5/7/2/9) and the system reapportions itself with a true mechanical advantage to the wheel with traction. Because the facial pressure of the side (bevel) gears is always equal, and the carrier rotates more rapidly than the stopped or slowed side (bevel) gear, a reduction (Phase Shift) sets up and torque is fed to the slower moving axle because it has been reapportioned to become the path of least resistance at a reduced speed. (This is observable in the video.)

This new link in the chain of torque is equal to the resistance to rotation experienced by the wheel in slip multiplied by the average aggregate reduction ratio of the opposing fixed differentials and fed in the form of torque to the wheel with traction. The wheel with traction begins to creep at the base ratio of the fixed differential (in this case 24:1), and as the wheel in slip gains traction the system reacts (Phase Shifts) by returning to torque to proper balance and proportion . The 24: 1 ratio can go through a variation (Phase Shift) of ratios in the process, but the fixed differential planets will ultimately assume a balanced straight forward mode unitary with both axles and the differential between them. Because, when relative motion of the carrier to axle stops, the fixed differentials become simple reductions which are locked in two gears ratios (speeds) at once making the entire axle between the wheels unitary in character. In this case the two speeds (gear ratios) are 1:1 through the ground-link and 1.0425:1 through the axle. The final path of least resistance is linear and the vehicle renews its forward motion. See NOTE 10

C. Explanation of an "aggressive" differential

An Automatic Variable Ratio Differential with the spur gear affixed to the side (bevel) gear being larger than the axle gear. (Drawing 7&4B Item 2 & 3 Photo # 4A&B Items 2&3)

A power train assembled with a rotational prime mover acting through a spider gear, spur gear or other Standard (open) differential of the types used in rolling stock and road vehicles, created to function as described above in explanation A. (Note: All differentials

perform the same task regardless of configuration.) Drawings 1 Fig. 1 & 2 Photo #6A Engineers Drawings Fig. 1,2 & 3

The two outputs of a standard (open) differential are affixed to a spur (sun) or annular gear of the same diameters and numbers of teeth respectively. (Drawing 4B & 7—Photo 4A&B Items 2&3) These two gears are set facially adjacent to a pair of spur (sun) or annular gears (attached to the final drives or axles) these axle gears have less teeth (or differ in tooth form so as the pitch diameters are smaller even if the outside diameters are equal) than those attached to the side (bevel) gears (Drawing 4B & 7—Photo 4A&B Items 8 & 9) (or differ in tooth form so as the pitch diameters are different even if the outside diameters are equal) than the gears mounted at the end of the outputs (Drawing 4B&7 Photo4A&B Items 2&3) of the standard (open) differential. (This set up tends to create a counter rotation on the slower moving axle and a forward rotation of the faster axle.) These rotations are second inputs as described in — Section 1 AA—and produce Phase Shifts within the system. All of the feedback and primary inputs are an aggregate which create the variable ratio. This ratio variation can be customized to apportion torque.

Planetary to the pairs of sun gears set up on each side of the standard (open) differential, and attached to rotate with the carrier yet free to revolve about their own center or shaft, are pairs (or a plurality) of planet gears each pair made as one, are two planet gears (Drawing 4B&7—Photo 4A&B Items 6/4 & 5/7) (The planets can be the gears with a difference in size or form) which are fitted to the sun gears in a way which creates a rotational attachment between them, and to an axle or other final drive. Such attachment and variation of size or form creates a reduction in reverse (which shows up to be same directional rotation as the carrier, on the bevel gears) to the prime direction of wheel rotation as described by the fixed differential (Section 1 AA) method and formulas, which in this configuration tend to retard rotation of the effected inside wheel. Also there are second inputs which vary the ratio (Phase Shift) of the effected fixed differential (SEE SECTION 1 AA and NOTE 10). These phenomena tend to bring the system into torque proportions by variations of mechanical advantage (ratio).

The outputs of such fixed differentials try to rotate in the counter direction of the carrier (Drawing 2&5 Right Side) and bevel gears try to rotate in the same direction as the carrier (Drawing 2 & 5 Left Side) with a ratio created by a small difference in number of teeth. When such devices are set up to oppose each other through a standard (open) differential as described (Drawing 7) and above they compliment the standard (open) differential and form the Aggressive Automatic Variable Ratio Differential.

The said planet gears (Drawing 4B& 7 — Photo 4A&B Items 6/4 & 5/7) physically attach the two suns on each side and make whole two axles or final drives. In a vehicle the ground completes the union. The ground-link torque and system union of the vehicle drive system can lose definition in a turn. In a current spider gear differential used alone this can cause loss of vehicle control especially in a high speed turn, because under some road surface conditions, when one wheel takes the inside, the outside wheel ~~will~~ only generate as

much facial pressure on the outside, side (bevel) gear as upon the slower moving inside side (bevel) gear which amounts to less forward thrust or torque on the outside wheel.

However in the Aggressive Automatic Variable Ratio Differential (Drawing 4B& 7 Photo 4 A&B) an additional link is created by the two fixed differentials (Drawing 4B&7 Photo 4 A&B Items 6/4/8/3 & 5/7/2/9) and the system reapportions itself.

The system seeks a torque proportioned positive traction by holding the side gears to the same facial pressure and the mechanical advantage of the fixed differentials bring the axles to proportioned torque instantly. (See part D. of the abstract in Section One)

This process operates proportionally throughout the maneuver of a left turn down to the vehicles smallest turning radius.

The entire axle between the two wheels assumes a unitary mode instantly for straight ahead and divides once more to proportion torque throughout the execution of a right turn.

(See part D. of the abstract for a description of our reaction to a slipping wheel as in a bog)

(C) There are complex relationships of ratio variation as described in (Section 1 AA and NOTE 10) and created by second inputs coming from the synergistic action of the several differentials. Because of the many variables in the system, a device is created which torque customizes itself (Phase Shifts) constantly. This device is very different from description B. but it has definite torque proportioning qualities. An almost endless array of possibilities arise when different ratios (B or C) are used on opposing sides of a differential (A) to accommodate known circles such as race tracks. But the fixed differential planets will assume balanced straight forward mode in unison with the differential when the vehicle is moving straight forward. The axle becomes unitary in character, and the ground link dominates a synergistic system. In this case 1:1 through the ground-link and .958:1 through the axle. The final path of least resistance is linear and the vehicle continues its forward motion. See NOTE 10

Although all drawings are of the external tooth type gears, it is considered obvious that annular gears will create the same results and helical etc. can be used.

Drawing #3 & 4A&B & 12--Photo #1

Explanation **D.** The preceding devices have 8 or more variables

We will now describe devices containing 10 or more variables.

Explanation of a creeping or aggressive differential with planetary assembly affixed to the side (bevel) gear (Photo #1) there being a ratio among the gears. (Items 9 & 2)

A power train assembled with a rotational prime mover acting through a spider gear,

spur gear or other standard (open) differential of the types used in rolling stock and road vehicles, created to function as described above in explanation A. (Note: All standard (open) differentials perform the same task regardless of configuration.) Drawings 1 Fig. 1 & 2 - Photo #6A

Engineers Drawings Fig. 1,2 & 3

The two outputs of a standard (open) differential are affixed to a spur (sun) gears of the same diameters and numbers of teeth. (Drawing Photo #1 Item #2) These two gears are set within a planetary assembly as in photo #1 to operate within a set of spur (planetary) gears (attached to the final drives, axles or second inputs by a set of annular gears one affixed to the carrier and one affixed to the wheel axle etc.) which have more or less teeth respectively (Photo #1 Items 9 & 2) (or differ in tooth form so as the pitch diameters are different even if the inside diameters are equal) than the gears mounted at the end of the outputs (Items 9 & 2) of the standard (open) differential. All of the feedback and primary inputs are an aggregate which create the variable ratio.

In a vehicle the ground completes the drive system union. (*note) The union of the vehicle drive system (open differential) can lose definition in a turn. In a current (open) differential used alone this can cause loss of vehicle control especially in a high speed turn, because, when one wheel takes the inside, the outside wheel will only generate as much facial pressure on the outside side (bevel) gear as upon the slower moving inside side (bevel) gear which amounts to less forward thrust or torque on the outside wheel.

However in the Automatic Variable Ratio Differential Photo #1 an additional link is created by the fixed differential (Photo #1 Items 6/4/8/3 & 5/7/2/9) and the system redefines itself with a mechanical disadvantage/advantage or other customized ratio to the the proper wheel. Because the facial pressure of the side (bevel) gears is always equal, and the carrier rotates more rapidly than the inside or slowed side (bevel) gear, a ratio sets up and torque is fed to the wheel the system is configured to favor in that circumstance. (Internal forward or counter rotational forces may set up inside this Automatic Variable Ratio Differential as determined by custom design.)

This new link in the chain of torque can be customized to road conditions (by gear ratio variations) and aid in vehicle control in traffic etc. or used to reduce the turning radius (produce facing movements) of such vehicles as fork-lifts etc. (C) There are complex relationships of ratio variation, created by second inputs coming from the natural action of the several differentials. Because of the many variables in the system, a synergetic device is created which customizes itself and re proportions torque constantly. This device can be similar to description B, C or E according to configuration, and it has definite torque proportioning qualities. An almost endless array of possibilities arise when different ratios (B or C) are used on opposing sides of any type differential (A) to accommodate known circles such as race tracks. But the fixed differential planets will ultimately assume balanced straight forward mode in unison with the differential. The axle becomes unitary in character, and the synergistic system is dominated by the ground link. In this case

1:1 through the ground-link and (1 : Plus or Minus) through the fixed differential planetary. The final path of least resistance is linear and the vehicle will renew its forward motion or adjust and proportion torque to road conditions. See NOTE 10

Although most drawings are of the external tooth type gears, it is considered obvious that annular gears will create the same results and helical etc. can be used. Drawings #3&4A&B—Drawings 9A, 9B, 9C, & 9D—Photo # 9AC&D

Variation of attachment points as in Drawing 10 give great variety to the configurations.

Drawings such as #12 illustrate the wide variety of configurations possible. In this configuration any of the additional variables such as Items 19, 20 21, 22 can vary in tooth number, point of attachment etc. and change the characteristics of the device.

E. Explanation of annular gear drive Drawings 3 & 4A&B

Similar to description B&C but based on two sets of annular gears as in Drawing 4A&B. Like all the other devices, there are probably neutral or benign configurations, but virtually any configuration that produces a ratio will perform.

E--Drawing 9A

Creeping/Aggressive Differentials Created to Use Planetary Sets (Low Ratio Fixed Differentials) (Described in Drawing 10, 11A&B)

Addendum to part E (Annular Devices)

Automatic Variable Ratio Differentials (AVRD)

A group of Unique torque-sensing and speed sensing (horse power sensitive) differentials which use a true mechanical ratio instead of mechanical friction to proportion torque between vehicle wheels.

Inventors Overview and summary——Bill Rogers

12/8/97

On December 3, 1997 I faxed drawings and other documentation of the following ideas to John Altman, Dr. TR Phillips, and talked to Marvin Zochart. Over the passing time since then we have built tested and observed a prototype. These devices represent the result of our on going research. The conception has been with us all along, these pages describe the reduction to practice of a preferred device.

1. Attachment of various inputs of planetary sets (ring, sun, carrier) Drawing 9A,10 & 11A&B Photo #9A to the outputs of a standard open differential of any type (bevel gear, spur gear, planetary gear, to include all limited slip differentials such as Torsen, Quaife and etc.) Drawings 1, Photo 6A while using the carrier ~~as 3~~ or multiple ~~inputs~~ and/or fixed points

of fixed differential type planetary sets Drawing 10 & 11A&B creates creeping or aggressive AVRDs according to configuration of ratios, types of devices and points of attachment.

Drawing 9A&10 Photo #9A

2. Whichever member of the system has the most reduction ratio (mechanical advantage) and least relative resistance under the circumstances of the moment is the input or path of least resistance for that moment. The device can alternate types, becoming either creeping or aggressive. Relativity is the essence of the system and points of input change with road conditions since the wheels through the ground link are feed back inputs to the system.

3. We have built and tested devices using planetary set design. The design used in this prototype connected: Drawing #9ABCD & Photo # 9ACD

I. The annulars (Items 15 &16) attach to the open differential carrier. (Item 12)

II. The sun gears attach to the side bevel gears of the open differential gears. Items 2 & 3

III. The planetary carrier is attached to the axles. Items 10 & 11

and we obtained the following results.

(A) All systems worked and went through all changes of character expected of this family of differentials, plus efficiency and integrity are very high .

(B) Because of the prototype size and parts availability, strong ratio advantage was not achieved, however this will be easier in the larger devices of actual practice. We used lawn tractor and automatic transmission planetary parts but expect the device to be used in cars, trucks, tractors, fork-lifts and other heavy equipment. The results achieved were very satisfactory and indicate a full size device would work even better. The unit built has many of the qualities (personalities) of both the aggressive and creeping AVRD since it has different variables in the system than the earlier prototypes. The most important things are that it becomes unitary for straight forward, differentiates for turns and phase shifts to adjust to ground link conditions.

The use of Limited Slip Differentials (LSD) in place of a standard open differential will add additional characteristics to any of these systems when such are desired. All these descriptions are to be considered cumulative.

There is a chronic need for a small indoor outdoor fork-lift for all terrain. This need is aggravated by the fact that present tire sizes needed to have traction on a counterbalanced fork-lift either make the wheel base longer than practical for indoor use or place the mast too far from axle center to be able to lift a heavy load and have a short wheel base. We believe the AVRD will help deal with this problem by allowing the use of smaller tires on an all terrain vehicle due to its Positively Traction feature and the Reversing Wheel features reduction of turning radius for better inside use.

Skid steering, fork-lifts, loaders, floor sweepers, lawnmowers, Zamboni, recreation vehicles etc. become practical.

E--Drawing 9A

Automatic Variable Ratio Differential (AVRD) Designed to Use Planetary Sets (Drawing 10) To Produce Aggressive and/or Creeping Effect

E.—Drawing 9 A — One version of a device designed to cause aggressive behavior An (AVRD) such as Drawing 9A Photo #9A is created wherein :

1. The axles are connected to the planetary carrier of the planetary sets. Drawing 9A Items 17 & 18
2. The shafts (Drawing 9A) from the side bevel gears of the open differential connect to the sun gears of the planetary sets. Drawing 9A Items 2 & 3
3. The 2 annular gears are rigidly attached to the open differential carrier. Drawing 9A Items 15 & 16

This creates a device that breaks up in a turn or spin out (Bog) situation to be like Drawing 10 Item 2 (Minimum Reduction) on the stopped axle, and like Drawing 10 Item 1 (Maximum Reduction) on the spinning axle. It is important to remember these are mirrors to each other when attached to the opposite ends of the open differential and stationary is relative in terms of least resistance, therefore Drawing 10 Item 1&2 swap sides and dominance constantly according to ground link conditions.

Since Drawing 10 Item 1 is a Maximum Reduction and Drawing 10 Item 2 is a Minimum Reduction, the path of least resistance tries to follow the wheel with traction. Horsepower circulates in the system and the path of least resistance changes constantly as the planetary sets adumbrate from (Drawing 10 Item 1 to Item 2) configuration and the system searches for a place to use horsepower efficiently.

This device addresses the same or similar circumstances as described in B. & C. and most descriptions may be considered cumulative. By variation of the base ratio in the two planetary sets the device can show qualities of both Aggressive and Creeping AVRDs.

Custom designs of similar nature can be created by the designs suggested by Photo #1 and all versions including the A, AA, B, C, Drawing 10 etc. can oppose each other effectively through any open differential or limited slip differential.

William D. and Richard Rogers Co-Inventors 1/8/97

E--Drawing 9B

Automatic Variable Ratio Differential (AVRD)
Designed to Automatically Reduce the Turning Radius of a Vehicle

One version of a device designed to cause the inside wheel to reverse thus creating a reduced turning circle in conjunction with the steering axle influence only. (Automatic)

E--Drawing 9B — An (AVRD) such as Drawing 9B is created wherein :

1. The axles are connected to the annular gears (Drawing 9B Item 15&16) of the planetary sets. Drawing 9B Items 23 & 24

2. The shafts (Drawing 9B Items 27 & 28) from the side bevel gears of the open differential connect to the planetary carrier of the differential sets. Drawing 9B Items 17 & 18

3. The 2 sun gears are rigidly attached to the open differential carrier at (Drawing 9B 25&26) and are hollow to allow passage of the shafts (27 & 28) connecting the side bevel gears to the 2 planetary set carriers. Drawing 9B Points 16 & 17

This creates a device that breaks up in a turn to be like Drawing 10 Item 3 (Reverse Reduction) on the inside axle, and like Drawing 10 Item 4 (Minimum Overdrive) on the outside. It is important to remember these are mirrors to each other when attached to the opposite ends of the open differential and stationary is relative in terms of least resistance.

Since Drawing 10 Item 3 is a reverse reduction and Drawing 10 Item 4 is a forward overdrive, the path of least resistance tries to reverse the inside wheel even as the outside wheel speeds around the turn. The result is a reduced turning radius of the vehicle. Variations of planetary set ratios can be custom configured to move the pivot point of the vehicle from place to place in the radius of the turn as required by pallet rack spacing etc. Thus increasing effective storage space.

The ground link connection in this device which has 3 points. That is to say, the two driven wheels will be allowed to input to the system only as the steering axle allows in terms of the forward radius and the reverse radius allowed by the steerage moving out of the way and to the side of the reversing driver. To be understood the vehicle should be thought of as two one wheel drives and then combined. Either driving wheel would provide motivation to the vehicle, this system allows the best of forward and reverse propulsion in a turn. The steering axle influence is dominant in a turn.

Some steering axle modification, such as a narrow stance etc., may be required. Modifications will be customized to each vehicle to accommodate an automatic maneuver. Also, custom designs of similar nature can be created by the designs suggested by Photo #1.

William D. and Richard Rogers Co-Inventors 1/8/97

E—Drawing 9C

Automatic Variable Ratio Differential (AVRD) Brake and/or Automatically Reduces the Turning Radius of a Vehicle

One version of a device designed to compliment automatic inside wheel reverse Drawing 9B and cause the inside wheel to reverse thus creating a reduced turning circle is created by adding brakes attached to the two Star Planetary carriers shown at Drawing 9C & Photo #9C Item 29&30–31&32.

E.— Drawing 9C—An (AVRD) such as Drawing 9C is created wherein :

1. The axles are connected to the annular gears of the planetary sets. Drawing 9C Items 23 & 24

2. The shafts (Drawing 9C Items 27 & 28) from the side bevel gears of the open differential connect to the planetary carrier of the planetary sets. Dwg 9C Items 17&18

3. The 2 sun gears are rigidly attached to the open differential carrier (at 25&26) and are hollow to allow passage of the shaft connecting the side bevel gears to the 2 planetary set carriers. Drawing 9C Points 25 & 26

This creates a device that breaks up in a turn to be like Drawing 10 Item 3 (Reverse Reduction) on the inside axle, and like Drawing 10 Item 4 (Minimum Overdrive) on the outside. It is important to remember these are mirrors to each other when attached to the opposite ends of the open differential and stationary is relative in terms of least resistance.

Since Drawing 10 Item 3 is a reverse reduction and Drawing 10 Item 4 is a forward overdrive, the path of least resistance tries to reverse the inside wheel even as the outside wheel speeds around the turn. The result is a reduced turning radius of the vehicle. Variations of planetary set ratios can be custom configured to move the pivot point of the vehicle from place to place in the radius of the turn as required by pallet rack spacing etc. Thus increasing effective storage space.

The ground link connection in this device which will have 3 points because of the influence of the steering axle (point 3). That is to say, The two driven wheels will be allowed to input to the system only as the steering axle allows in terms of the forward radius and the reverse radius allowed by the steerage moving out of the way and to the side of the reversing driver. To be understood the vehicle should be thought of as two one wheel drives (similar to individual hydraulic motors on each wheel, with independent forward reverse control) and then combined. Either driving wheel would provide motivation to the vehicle, this system allows the best of forward and reverse propulsion in a turn. The addition of a brake assembly at Drawing 9C & Photo # 9C Item 29/30 & 31/32 gives the system operator control by a joy stick or other device on a vehicle such as a bulldozer or other skid steering device.

Some steering axle modification, such as a narrow stance etc., may be required. Modifications will be customized to each vehicle to accommodate this maneuver. Also, custom designs of similar nature can be created by the designs suggested by Photo #1.

Fork-lift Advantages

2/8/98

The present arrangement of drive train pull mechanism of a counterbalanced fork-lift designed to work in field conditions of gravel, mud or off-road, creates the following set of forces when a hard left turn such as figure 1 is executed:

Reference Drawing 13 which represents a counter balanced fork-lift.

Wheel 1 & 2 both pull with equal torque, forward. Vector A & B

Wheels 2 & 3 experience a side pull. Vector C & D Because this side thrust is high resistance sliding friction, a path of least resistance is found in the direction of the rolling friction path represented by Vectors E & F. This path is taken only as the steering tires are dragged along, which in soft ground or even gravel or soft asphalt often results in plowing, dozing and digging. Due to the nature of an open differential and the angle of attack of 3 & 4, only wheel 2 is truly pulling wheel 3 & 4 toward Vector E & F. Wheel 1 is mostly dragging wheels 3 & 4 toward Vector C &D.

Now note the devices described in the Drawing 9 series, and more particularly those reversing devices which use a brake to implement reverse. Specifically Drawing 9C and Photo 9C which when in a turn can be controlled to produce a reduction ratio on the reversing wheel (1) and and overdrive on the forward wheel (2) or vice versa. When such devices replace the standard open differential in axle 6 a field of vectors are created such as figure 2 Wherein:

Wheel 1 pulls with a reduced speed and higher torque in reverse toward Vector G.

Wheel 2 pulls forward with greater speed and less torque toward Vector B.

Wheels 3 & 4 experience reduced side pull along Vector C & D.

The resulting swing motion of axle 6 toward G & B reduce and avoid the sliding of wheels 3 & 4 along C & D and compliment each other in moving 3 & 4 toward E & F while avoiding the ground deformation described above.

Since power is more properly directed to the desired purpose, less traction is wasted on useless effort, both 1 & 2 work together, and the AVRD quality of 9C helps maintain traction in forward motion of the fork-lift; smaller tires can be used on axle 6 at 1 & 2. Reduced tire size will bring the position of mast 5 closer to the loaded lifts pivot point at the center of axle 6 which will reduce the wheel base and/or counter weight size necessary to carry a specific load. For these reasons and more, a smaller drive train and engine will move the same payload.

We have described a fork-lift of reduced size and or weight, which is more maneuverable, cheaper to build, will work in less space and do less damage to the ground or pavement.

E--Drawing 9D

Automatic Variable Ratio Differential (AVRD)
Brake and/or Automatically Actuated
Designed to Reduce the Turning Radius of a Vehicle

One version of a device designed to compliment automatic inside wheel reverse Drawing 9B and cause the inside wheel to reverse thus creating a reduced turning circle is created by adding brakes attached to the two Planetary carriers shown at Drawing 9D & Photo #9D Item 29&30 31&32

E. -- Drawing 9D--An (AVRD) such as Drawing 9D is created wherein :

1. The axles are connected to the sun gear of the planetary sets.
   Drawing 9D Items 10&11 to 2&3
2. The shafts (Drawing 9D & Photo 9D Items 27 & 28) from the side bevel gears of the open differential connect to the planetary carrier of the planetary sets.
Drawing 9D Items 17 & 18
3. The annular gears (Item 15 &16) are rigidly attached to the open differential carrier. (Item 12)

This creates a device that breaks up in a turn to be like Drawing 10 Item 6 (Reverse Over Drive) on the inside axle, and like Drawing 10 Item 5 (Maximum Overdrive) on the outside. It is important to remember these are mirrors to each other when attached to the opposite ends of the open differential and stationary is relative in terms of least resistance.

Since Drawing 10 Item 6 is a reverse overdrive and Drawing 10 Item 5 is a forward overdrive. The result is a reduced turning radius of the vehicle. Variations of planetary set ratios can be custom configured to move the pivot point of the vehicle from place to place in the radius of the turn as required by pallet rack spacing etc. Thus increasing effective storage space.

The ground link connection in this device which will have 3 points because of the influence of the steering axle (point 3). That is to say, The two driven wheels will be allowed to input to the system only as the steering axle allows in terms of the forward radius and the reverse radius allowed by the steerage moving out of the way and to the side of the reversing driver. To be understood the vehicle should be thought of as two one wheel drives (similar to individual hydraulic motors on each wheel, with independent forward reverse control) and then combined. Either driving wheel would provide motivation to the vehicle, this system allows the best of forward and reverse propulsion in a turn. The addition of a brake assembly at Drawing 9D Item 29/30 & 31/32 attached to the planetary set carrier (Item 17 &18) gives the system operator control by a joy stick or other device on a vehicle such as a bulldozer or other skid steering device.

Some steering axle modification, such as a narrow stance etc., may be required. Modifications will be customized to each vehicle to accommodate this maneuver. Also, custom designs of similar nature can be created by the designs suggested by Photo #1.

E- Drawing 9F

Automatic Variable Ratio Differential (AVRD) Brake and/or Automatically Reduces the Turning Radius of a Vehicle

One version of a device designed to compliment automatic inside wheel reverse and cause the inside wheel to reverse thus creating a reduced turning circle is created by adding brakes attached to the Planetary Sets Carriers (as in Photo # 1)shown at Drawing 9F Item 29&30—31&32.

E.— Drawing 9F—An (AVRD) such as Drawing 9F is created wherein :

1. The axles are connected to annular gears gears of the planetary sets. Drawing 9F Items 35 & 36

2. The shafts (Drawing 9F Items 27 & 28) from the side bevel gears of the open differential connect to the Sun Gear of the planetary sets. Drawing 9F Items 2 & 3

3. The 2 Annular gears are rigidly attached to the open differential Carrier Drawing 9F Item 12

4. The Planets 4 & 5 which are held in a floating carrier are extended to rotationally attach to the annular gears Item 35 & 36 this creates a new device with unique properties which can be configured in terms of fixed differential ratios such as those already described a (and those related to Photo #1) to create a controlled reverse of the inside wheel of vehicle to facilitate a shorter turning radius. A disc brake and shoe 29 & 30—30 & 31 add operator control to the system.

The ground link connection in this device which will have 3 points because of the influence of the steering axle (point 3). That is to say, The two driven wheels will be allowed to input to the system only as the steering axle allows in terms of the forward radius and the reverse radius allowed by the steerage moving out of the way and to the side of the reversing driver. To be understood the vehicle should be thought of as two one wheel drives (similar to individual hydraulic motors on each wheel, with independent forward reverse control) and then combined. Either driving wheel would provide motivation to the vehicle, this system allows the best of forward and reverse propulsion in a turn. The addition of a brake assembly at Drawing 9F Item 29/30 & 31/32 gives the system operator control by a joy stick or other device on a vehicle such as a bulldozer or other skid steering device.

Some steering axle modification, such as a narrow stance etc., may be required. Modifications will be customized to each vehicle to accommodate this maneuver. Also, custom designs of similar nature can be created by the designs suggested by Photo #1.

William D. and Richard Rogers Co-Inventors 2/1/98/98

E-Drawing 9G

Automatic Variable Ratio Differential (AVRD) Brake and/or Automatically Reduces the Turning Radius of a Vehicle

One version of a device designed to compliment automatic inside wheel reverse and cause the inside wheel to reverse thus creating a reduced turning circle is created by adding brakes attached to the Planetary Sets Carriers (as in Photo # 1)shown at Drawing 9G Item 29&30–31&32.

E.— Drawing 9G—An (AVRD) such as Drawing 9G is created wherein :

1. The axles are connected to the sun gears of the planetary sets. Drawing 9G Items 33 & 34

2. The shafts (Drawing 9G Items 27 & 28) from the side bevel gears of the open differential connect to the Sun Gear of the planetary sets. Drawing 9G Items 2 & 3

3. The 2 Annular gears are rigidly attached to the open differential Carrier Drawing 9G Item 12

4. The Planets 4 & 5 which are held in a floating carrier are extended to rotationally attach to the sun gears Item 33 & 34 this creates a new device with unique properties which can be configured in terms of fixed differential ratios such as those already described (and those related to Photo #1) to create a controlled reverse of the inside wheel of vehicle to facilitate a shorter turning radius. A disc brake and shoe 29 & 30–30 & 31 add operator control to the system.

The ground link connection in this device which will have 3 points because of the influence of the steering axle (point 3). That is to say, The two driven wheels will be allowed to input to the system only as the steering axle allows in terms of the forward radius and the reverse radius allowed by the steerage moving out of the way and to the side of the reversing driver. To be understood the vehicle should be thought of as two one wheel drives (similar to individual hydraulic motors on each wheel, with independent forward reverse control) and then combined. Either driving wheel would provide motivation to the vehicle, this system allows the best of forward and reverse propulsion in a turn. The addition of a brake assembly at Drawing 9G Item 29/30 & 31/32 gives the system operator control by a joy stick or other device on a vehicle such as a bulldozer or other skid steering device.

Some steering axle modification, such as a narrow stance etc., may be required. Modifications will be customized to each vehicle to accommodate this maneuver. Also, custom designs of similar nature can be created by the designs suggested by Photo #1.

William D. and Richard Rogers Co-Inventors 2/1/98/98

E- Drawing 9H

Automatic Variable Ratio Differential (AVRD) Brake and/or Automatically Reduces the Turning Radius of a Vehicle

One version of a device designed to compliment automatic inside wheel reverse and cause the inside wheel to reverse thus creating a reduced turning circle is created by adding brakes attached to the Planetary Sets Carriers shown at Drawing 9H Item 29&30—31&32.

E.— Drawing 9H—A differential such as Drawing 9H is created wherein :

1. The axles are connected to the sun gears of the planetary sets and also attached to the side bevel gears of the open differential. Drawing 9H Items 10, 3 &27—11, 2 & 28 The shafts (Drawing 9H Items 27 & 28) from the side bevel gears of the open differential connect to the Sun Gear of the planetary sets and are also the one piece axle.

3. The 2 Annular gears are rigidly attached to the open differential Carrier Drawing 9H Item 12

4. The Planets 4 & 5 which are held in a floating carrier rotationally attached to the sun gears Item 2 & 3 and the annular gears 16 & 15 this creates a new device with unique properties to create a controlled reverse of the inside wheel of vehicle to facilitate a shorter turning radius. A disc brake and shoe 29 & 30—30 & 31 add operator control to the system. Floating carriers remove the mirror action and the two axles can react to only one planetary set.

The ground link connection in this device which will have 3 points because of the influence of the steering axle (point 3). To be understood the vehicle should be thought of as two one wheel drives (similar to individual hydraulic motors on each wheel, with independent forward reverse control) and then combined. Either driving wheel would provide motivation to the vehicle, this system allows the best of forward and reverse propulsion in a turn. The addition of a brake assembly at Drawing 9H Item 29/30 & 31/32 gives the system operator control by a joy stick or other device on a vehicle such as a bulldozer or other skid steering device.

In the device we have tested the planetary set ratio is slightly more than 2 : 1. This means the held planetary produces 2 : 1 Overdrive in reverse. The device we tested has roughly 2 Revolutions of reverse and 4 revolutions forward per revolution of the carrier as in 9D.

Some steering axle modification, such as a narrow stance etc., may be required. Modifications will be customized to each vehicle to accommodate this maneuver. Also, custom designs of similar nature can be created by the designs suggested by other drawings in this paper. **William D. and Richard Rogers Co-Inventors 2/1/98/98**

E- Drawing 9I

Automatic Variable Ratio Differential (AVRD) Brake and/or Automatically Reduces the Turning Radius of a Vehicle

One version of a device designed to compliment automatic inside wheel reverse and cause the inside wheel to reverse thus creating a reduced turning circle is created by adding brakes attached to the Planetary Sets Carriers shown at Drawing 9I Item 29&30–31&32.

E.— Drawing 9I—A differential such as Drawing 9I is created wherein :

1. The axles are connected to the Annular Gears of the planetary sets and also attached to the side Bevel Gears of the open differential. Drawing 9I Items 10, 16 &27–11, 15 & 28

The shafts (Drawing 9I Items 27 & 28) from the side Bevel Bears of the open differential connect to the Annular Gear of the planetary sets and are also the one piece axle.

3. The 2 Sun gears (Item 2 & 3) are rigidly attached to the open differential Carrier Drawing 9I Item 12

4. The Planets (Items 4 & 5) which are held in a floating carrier rotationally attached to the sun gears Item 2 & 3 and the annular gears 16 & 15 this creates a new device with unique properties to create a controlled reverse of the inside wheel of vehicle to facilitate a shorter turning radius. A disc brake and shoe 29 & 30–30 & 31 add operator control to the system. Floating carriers remove the mirror action and the two axles can react to only one planetary set.

The ground link connection in this device which will have 3 points because of the influence of the steering axle (point 3). To be understood the vehicle should be thought of as two one wheel drives (similar to individual hydraulic motors on each wheel, with independent forward reverse control) and then combined. Either driving wheel would provide motivation to the vehicle, this system allows the best of forward and reverse propulsion in a turn. The addition of a brake assembly at Drawing 9I Item 29/30 & 31/32 gives the system operator, control by a joy stick or other device on a vehicle such as a bulldozer or other skid steering device.

In the device we have tested the planetary set ratio is slightly more than 2 : 1. This means the held planetary produces 2 : 1 Reduction in reverse. The device we tested has roughly 1/2 Revolution of reverse and 2.5/1 revolutions forward per revolution of the carrier as in 9C.

Some steering axle modification, such as a narrow stance etc., may be required. Modifications will be customized to each vehicle to accommodate this maneuver. Also, custom designs of similar nature can be created by the designs suggested by other drawings in this paper. William D. and Richard Rogers Co-Inventors 2/1/98/98

F. Description of an infinitely variable drive:

A device can be constructed as in Drawing # 8 by replacing one of the fixed differentials with a variable speed motor or adding such motor where a wheel would normally be. In such a device the mechanical advantage could be changed without changing gears as by a shifting gear box. The direction of rotation could also be changed smoothly without a reversing-gear mechanism being shifted in or out. Since the device is strictly a mechanical device using conventional gear meshes of known efficiencies, I expect it would be uniformly efficient over its full range of operation. Typically fluid drive systems have large volumetric losses at the low-speed-high-torque (l-s-h-t) end of their operating spectrum. Variable speed electric motors also have problems with l-s-h-t performance. With the electrical system a gear box can usually be found to satisfy the l-s-h-t situation, but then the high speed performance is significantly reduced.

This device will operate equally well throughout its operating range. It will have the capacity to seek maximum efficiency, especially when a system of programmable logic controllers are assigned to help make decisions. Drawings 9C&D – Photo # 9C & 9D have been observed to have three forwards and one reverse on each axle. These lend well to the flywheel devices especially when opposing devices are mix matched.

G. Description of X-Super Creeping / X- Super Aggressive (using idler gearing)
We built such a device and ran it, but we did not photograph it before using some of the parts in another device. It is interesting to note that it seemed at first to have no exclusive purpose. However, reflection makes me realize, it had a pre-loaded personality. Like an almost positive traction (Spool) unit that can reluctantly go through differentiation.
This device is created by using a pair of suns which greatly differ in size. Which of the two is larger determines the personality of the device (Creeping or Aggressive). We relabled a photograph of another device to represent this unit. Photo #7 An elongated straight planet is used to engage the larger sun and an idler gear is used to connect one end of the elongated planet to the smaller sun. We believe this set up will have custom uses.
NOTE: The device described in Drawing 9D and E–Drawing 9D has these qualities of pre-load.

Note: These are only a few of many configurations based on this idea. The new principles common to all of them are:

1. Any epicycle or hypocycle which will transform (phase shift) from a fixed differential (Two inputs at once capacity) to an ordinary gear ratio based on two gears running tangent to each other (not two inputs at once capacity) used in conjunction with an open differential like a valve to open and close the system and provide torque proportioning Variable Ratios, with interactive dynamics is an Automatic Variable Ratio Differential.
2. I have observed a large difference in braking torque on the stopped wheel in the device which I believe is the systems spontaneous (synergistic) search for a RATIO which will break

inertia or static friction and continue by gaining speed by changing ratios in proportion to the difference in static and dynamic friction or inertia. Observation also indicates that the systems range of ratio is not limited to the parameters of the base ratios.
That is to say, the phase shift process can introduce ratios much greater than the 24:1. Even ratios close to infinity are theoretically possible under certain conditions. But no damage can occur since the device can never exceed carrier torque. Experimentation will eventually find the best base ratios.

3. The several explanations above are cumulative in nature to avoid redundancy. That which is true of one applies to all, but it may apply differently.

4. In creeping form the ratio sent to the wheel with traction starts at (Base Ratio) 24:1 in the models we built and works down. The planetary set devices we actually built have so far (1/24/98) had ratios in the range of 2:1 to 3:1 but greater ratios are available in planetary sets (up to 12:1) and we expect better results from them. The devices we built work surprisingly well. The planetary set devices 97% efficiency is an advantage in some ways, but the low efficiency of fixed differentials can also be an advantage to some devices.

5. In aggressive forms the ratio sent to the wheel with traction starts at about 1:1 and works up to that necessary to move the vehicle or become a unitary axle, in both cases this happens very quickly and automatically. Another theory of this operation is the over drive in an aggressive AVRD built with planetary sets such as <u>Drawing 9D Photo 9D</u> biases torque to the wheel with traction because the stopped or slower wheel is easier to move than the spinning wheel is to speed up. This characteristic is that which causes this device to favor the automatic reversing of the inside wheel of a vehicle in a turn according to the angle of the steering axle and the corresponding steering axle influence on the ground link. This is accomplished by a spontaneous reverse of the side bevel gear of the open differential and the planetary carrier attached to it. This can stop the planetary carrier and cause the reverse of the inside wheel by the carrier influence or go farther and increase that reverse by complimentary rotation of the planetary set carrier.

6. Transition (phase shift) to both simple and compound ratios (based on epicycles and hypocycles in fixed differentials , the ratio of which are created by relatively similar size gears working off small differences in number of teeth see Section 1 AA, AAA & Section 3 B .) operating together to create one linear or two curvilinear outlets in a turn, with analog torque proportioning capability. This can also be achieved using planetary sets as in Drawing 10, 11A&B.

7. Transition (phase shift) to one high traction outlet with a <u>Multiplied Ratio</u> and one low traction rotary outlet when one axle rotates faster than the other as in a bog.

8. The effect of the Automatic Variable Ratio Differential is to create (2-4 or multi-wheel drives) wherein each wheel is capable of automatic shifts to proportional torque operation. Each axle becomes capable of variable ratios which send torque to the axle with traction. The effect is similar to one wheel pulling, because the system is so cooperative as to pull together.

9. In an instance when a wheel loses traction any resistance given to the free spinning side helps bring the planet pinion input (fixed differential Section One Explanation AA or AAA or planetary sets Drawing 10, 11A & B) into play and ratio variation begins to feed torque to the wheel with traction. (A brake or automatic traction system can supply the initial resistance.) The presence of the brake on the planetary carrier of the planetary sets of Drawing 9C & 9D or Photo 9C & D adds the reversing factor to the mix of utilities of the AVRD systems.

NOTE 10. A definition of PHASE SHIFT: The ability of the epicycle (fixed differential) or hypocycle (planetary sets) to operate concurrently (use multiple inputs) allows the system of the Automatic Variable Ratio Differential to internally hesitate, stop, reverse, and create a variable ratio at the outputs of a standard (open) differential. The addition of an extraneous source of motion, such as is introduced by the planet gear of the fixed differential (or planetary set) when the carrier revolves faster (or slower) than an axle sun gear, planetary set carrier etc., has the effect of varying the number of teeth in the sun or annular gears. This can effect the speed (ratio), torque, and internal direction of motion. This amounts to an infinitely variable (in torque and speed) pair of transmissions which operate complimentary to the standard (open) differential and to each other, to proportion both Speed & Torque (HORSEPOWER) between the wheels of a vehicle in response to variations in ground conditions.

A. The 5 or more inputs of an AVRD are:

1. Three from the unitary carrier. 2. Two from the ground link of the axle tires. 3. One from the steering axle ground link 4. Other Static or rotary inputs such as those introduced at the planetary carrier of the Drawing 9C & 9D to create single axle reverse.

Any one or any combination of these inputs, responds instantly to changes in relative speed among themselves, and causes the gear system to change phase relationship. Since the governing factor in this system is the path of least resistance, the corrections of torque and speed respond to changes in ground conditions as experienced separately by the tires and communicated to the system by the ground link of the two tires in a cooperative fashion.

A phase shift occurs in the system, each time a driven gear changes its' relative pitch diameter by increase of speed in the same relative direction as its' prime mover (losing relative size) or slowing, stopping or reversing (gaining relative size) and vice versa. This is a process which resembles slippage, but does not slip.

It is this process which causes the system to seek the wheel which has traction and can accept the bulk of carrier torque and place it there at a reduced RPM, then begin to search for the maximum speed at which the wheel with traction can accept horsepower, even as it cooperates with changing ground conditions at the tire that was slipping, by communicating with the prime mover through the ground link.

B. An epicyle is a circle traced on a circle and refers in this document to planet gears with external teeth running against sun gears with external teeth.

Example: Explanation AA.

C. A hypocycle is a circle within a circle and refers in this document to planet gears with external teeth running against the inside internal toothed gears with or without a sun gear present. Example: Drawing 11A, 11B &12

11. The Automatic Variable Ratio Differential (AVRD) is compatible with any present Torque Control System (TCS) or Break Torque Control System (BTCS) or any differential may be used in place of the Standard (Open) Differential.

12. It is understood that a variation of size in one or a combination of all gears of the fixed differential or planetary set can produce a desirable ratio. This makes the personality of a system hard to predict except by experiment but once identified it is constant.

A variation of these devices can create a perfect power divider (transfer case) for 4 wheel drive vehicles. We will be continuing our research into completely new areas where control is required to be more perfect or custom. A system of programmable logic controllers can control these devices through brakes or second rotational input drives to distribute torque and maintain constant output speed while the prime mover varies in speed or vice versa. A variation can be built to take the place of a torque converter ahead of current automatic transmission to absorb road shock and eliminate the slippage, inefficiency and gas mileage loss now experienced with automatic transmissions, or store energy in a flywheel for later use. This concept of control is true of any differential device (center) used in conjunction with all fixed differentials (attached to sides) such as: Dudley's Gear Handbook Fig. 3.24 Pg. 3.30, Planetaries, Sumitomo, orbi-drive, planocentric, Winnsmith fixed differentials or etc. Outboard motor foot. Two motor input one output. One input, two outputs.

William D. & Richard Rogers 7/7/97
UPDATED

Automatic Variable Ratio Differential (AVRD)

Advantages

1. A rotating differential carrier wherein are located three attachment inputs connected to epicyclic trains. Said epicyclic trains are further attached among themselves so as to form both rotary and static relationships as dictated by external resistance to rotation of the multiple input/output carrier. Such resistance can be entered by multiple output/inputs as interrelated by a ground link or by single inputs such as brakes or rotary inputs. By means of this system a single input is able to interact as four or more cooperative drives. These are:

I. The open differential carrier
II. The left side of the open differential
III. The right side of the open differential
IV. The left and/or right planetary sets
V. Intricate combinations of the above

2. The result of #1 is a device wherein torque and speed interrelate to make efficacit use of available differential horsepower.
3. Another result of #1 is the expansion of stress moment in the members of a drive train by means of ratio variation (phase shifts) of horsepower components, hence elimination of torque shock.
4. Another result of #1 is better gear braking on mountain roads, because the stress moment of spin out is lengthened.
5. Another result of #1 is concentration of horsepower on the wheel with traction in a bog because the AVRD can be designed to be torque and speed (Horsepower) sensitive.
6. Another result of #1 is better horsepower distribution among the wheels of a vehicle under all road conditions especially in turns. Use of this device as a power divider extends said horsepower distribution advantages to all wheels and among the axles of a multiple axle drive.
7. A device with multiple outputs some of which are capable of reversing direction of rotation either automatically or by operator control without reversing the input or all of the outputs. This makes possible multiple speed transmissions based on the AVRD.
8. Since there are 6 possible driving, stationary, or driven members to the planetary sets, there are 6 possible opposing combinations on each side of the open differential. Opposing combinations equals at least 6x6 = 36 possible combinations, to describe them all is unnecessary to building them all.
9. The term planetary sets refers to configurations similar to Drawing 10, the term fixed differential refers to explanation (AA).
10. The versions of the AVRD described in explanations E Drawing 9B, E Drawing 9C and E Drawing 9D--Photo #9C & 9D are each capable of reversing the inside wheel in response to ground conditions when a vehicle is in a turn and/or when a braking device is applied. These are but a few of the possible devices. Fixed differentials (AA) can also be used to create these effects or mixed and matched with open differentials and other epicyclic trains to customize a power transmission system..

We have constructed the AVRD using: STAR, SUN, SOLAR, PLANETARY and FIXED EPICYCLIC GEAR SETS. It is also possible to build the device using COMPOUND PLANETARY, COMPOUND STAR, COMPOUND SOLAR gear sets as described in the Dudley's Gear Handbook and etc., coupled as in Drawing 10.

Uses of the shortened turn radius devices (reverse inside wheel) are Wheel Chairs, Robots, Weapons, General Fork-lift Operation, lawn mowers, floor sweepers etc.

Some observations of the reversing wheel AVRD:

1. Any planetary set member which can be reached while the AVRD is in operation can be alternately or partially released and held to cause independent forward and reverse and change of speed of either output without regard to input direction or speed. This method produces 3 forwards and one reverse speed at each output.

2. Variables involved in determining the turning radius limitations are: Wheel Stance, Wheel Base, Base Ratio of the AVRD etc.

3. It is possible to use infinite variations of the reversing AVRD's to create variable speed, automatic, semiautomatic and manual transmissions with multiple speeds, reverses and outputs.

4. All AVRD's lengthen the stress moment of torque engagement and thus absorb torque shock.

5. Various versions of the reversing AVRD are possible based on photo #1 and/or using a free and/or fixed annular.

6. NOTE: Any AVRD will operate and function well with any differential (limited slip device etc.) regardless of the ratio in the open differential. (2:1 or more or 2:1 or less.)

7. Farther variations of the AVRD are possible using compound planetary and/or fixed differentials on the bevel gears of the open differential to create unique affects. Coupling variations such as Drawing 10 add to the variations.

11. The variables of these systems are:

1. The ratio of the fixed differentials (AA) or planetary sets (Drawing 10)

2. Configuration of rotary and static attachment (Drawing 10 Items 1 through 6)

3. It is considered obvious that any place (in all of these text or drawings) a static input such as a brake is suggested, a rotary input is possible and may find uses.

4. Variation of any one of these factors influences all phases of the AVRDs' personality dramatically.

12. These inventions are unique and practicle and a breakthrough in their field. Because they maintain speed in a general turn, shift speed to torque in a bog and when these are combined the AVRD buffers torque variation and speed variation in a turn and avoids tire spin out in slick road conditions.

Section Two

Creeping Automatic Variable Ratio Differential

Inventors Overview – Richard Rogers Co-inventor

Note: This section describes only the

A description of a (A) standard open differential and a (AA) fixed differential which combine to form:

(B) Creeping Automatic Variable Ratio Differential

A Unique torque sensing and speed sensing (horse power sensitive) differential which uses a true mechanical ratio instead of mechanical friction to proportion torque between vehicle wheels.

8/3/97

Reference Disclosure Document # 379469 April 3, 1996

This invention embodies the use of standard differential axle coupled with what is known as a fixed differential (a differential is most basically defined as a gearing system with multiple possible inputs or outputs).

The operation of a standard bevel gear differential will be briefly explained for more effective understanding of this invention and its improvement / advantage over present devices methods. See Drawings 1 Fig. 1 & 2 - Photo #6A Engineers Drawings Fig. 1 & 3

This gearing arrangement obeys the following laws:

1. If the right wheel is not turning, or turning slower than the carrier, and the carrier is turning "X" speed, the spider gears "walk" upon the right axle side (bevel) gear (the left side could easily be the side examined just the same way).

When this effect takes place, the spider gears' revolving acts upon the left wheel in an opposite manner (referring to wheel speed) this movement compounds with the speed (X) of the differential carrier.

2. In the event that there is a speed difference between the right and left wheels, their speeds when combined and then divided by two will equal the speed of the differential carrier. If

there is no speed difference, this law still holds.
3. Pressure on the tooth faces of the spider and side (bevel) gears is always equal.
4. Forward motion of the vehicle is produced by pressure applied by the wheels to the ground (tractive force).

Tractive force can be no greater than twice the value of the least efficient wheel's effort (thus obeying law #3—the side (bevel) gears are what ultimately drive the wheels).

5. When tractive force falls below the value needed to propel the vehicle forward, motion stops, no matter how much possible traction the best grounded wheel has. Tractive force lost completely or nearly so can easily stop a vehicle's motion.

Brief Explanation of a Fixed Differential (Drawing #5)

While many combinations have been successful in producing the effects qualifying a device as a fixed differential, the one quality most essential to our invention's operation is a concentric input and output.

For the simplest explanation, I will choose to illustrate the invention using a fixed differential of the spur-gear-type using a single planetary gear. Engineers Drawing Fig. 2—Drawing 5

This arrangement will obey the following laws:
1. When the right axle is fixed, turning the planet about it will result in a 24:1 movement in the same direction from the planet carrier by the left axle. Drawing 5

2. When the planet carrier is fixed and the right shaft is turned, the opposite revolves in the same direction with a ratio of 24/23:1 reduction. Drawing 5

3. When the left axle is fixed, and the planet carrier turned, the right axle will rotate at a ratio of 23:1 in the opposite direction as the carrier's rotation. Drawing 5

4. When the planet carrier is fixed and the left shaft is turned, the right shaft revolves in the same direction with a 1:23/24 overdrive. Drawing 5
*Note: this type of gear reducer can be built with spur, annular and other gears, or combinations of them. Drawing 3

Combination of Afore mentioned Devices

Our invention's mode of operation depends upon the proper unifying of the previously mentioned devices.

I shall present the following example to illustrate its operation {this device has been built,

and studied by the inventors. It has also been and is being assessed and evaluated by our Professional Engineer, Marvin L. Zochert of Pineville, LA. Mr. Zochert also has his own work briefly detailing the invention(s)}. See Drawing #6 – Photo #3A&B

Creeping Differential Drawing 3A & 6

Description of Components:

(A) Planet gears have 12 teeth each. These in this case are wide enough gears to engage teeth on both the inner and axle spur gears at once.

(B) Axle gears are 24 tooth spur gears.

(C) Inner spur gears are 23 teeth each.

(D) Remainder of design is basically a standard (open) differential.

In our tests, we observed the following characteristics of the above described device:

*When one axle shaft was held from turning, the opposite axle shaft turned twice the speed of the carrier. This is the same law a standard differential would obey.

*Any resistance put on the freely spinning axle mentioned before causes the following behavior:

The resistance given is fed back through the devices gear train and makes an effort to rotate the "held" wheel just like a standard (open) differential (one input).

At this point the planet is now at its zenith of influence one the "held" wheel and imparts a <u>Multiplied</u> tendency to rotate the "held" wheel forward (2nd input). This is in obedience to law #3 regarding fixed differentials.

*We have given a mechanical advantage to the standard (open) differential that gives it very much improved behavior in snow, mud, or other low traction conditions.

*The inventions use of <u>two</u> inputs to the wheel with the most usable traction potential makes it truly superior to present systems using clutches in the differential. Our device is very compatible with anti-lock brakes, and does not bother normal steering under normal driving conditions, as clutches now have problems in these areas.

* This device will last the normal lifetime of vehicles in which it is used.

SUMMATION

*The more the carrier's speed outpaces that of either side's sun gears, the more influence the input involving the planet will have.

*The closer to the same speed the sun gears are to the carrier the more influential the side gear's input will be upon the wheel(s) in question. The axle that is going faster than the carrier is also most heavily influenced by the side gear's input.

*Going straight ahead in the vehicle, the differential gears throughout the assembly will not be rotating in relation to each other.

Richard Rogers

Section Three

Automatic Variable Ratio Differential

Professional Engineers Overview
An analysis of the operating device written at the request of the inventors
Written by– Marvin Zochert P. E.
Inventors: Bill and Richard Rogers
Reference Disclosure Document # 379469 April 3, 1996

General description of device:

A. Explanation of a standard (open) differential.

A differential gear system divides the torque of a rotational prime mover between the two axle shafts of a vehicle and allows them to rotate at different speeds when turning corners. The operation of a typical bevel-gear automotive differential is shown in (Engineers Fig. 1). There are other configurations as well, but they all involve the use of a ring gear, some planet gears, a planet carrier, and two output shafts. Basically, the prime mover (1) provides the input to the differential through the drive shaft pinion (2). The ring gear (3), which also acts as the planet carrier, is driven by the drive shaft pinion. The planet gears (4) are mounted on stub-shafts fixed to the carrier and orbit the output shaft axis at the same speed as the ring gear. Output gears (5&6) are connected to the output shafts (7&8) of the differential which are subsequently connected to the rear wheels of the vehicle. Thus, when the vehicle is traveling in a straight line, the two gears (5&6) revolve at the same speed and there is no relative motion between the planet gear (4) and the two output gears (5&6). The planet gears serve only to transmit motion from the planet carrier to both wheels.

When the vehicle is making a turn, the inside wheel makes fewer revolutions than the outside wheel because of its shorter turning radius. If this difference of speed between the two wheels were not compensated for in some way, one or both of the wheels would have to slide to make the turn. The differential allows the wheels to rotate at different rotational

speeds while at the same time delivering power to both. While in a turn, the planet gears (4) rotate on their stub-shafts and permit output gears (5&6) to revolve at different speeds relative to one another.

It can easily be seen that if one output shaft is stopped, the other will rotate at twice the speed of the ring gear. The differential's purpose is to differentiate between the speeds of the two wheels. In the usual automobile differential, the torque is divided equally no matter whether the car is moving in a straight line or not. Often road conditions are such that the tractive effort that can be developed by the two wheels is unequal. When this happens, the total tractive effort available will be only twice that of the wheel having the least traction, because the differential divides the torque equally. Should one wheel be resting on snow or ice, the total effort available is very small and only a small torque will cause the wheel to spin.

In the differential shown in (Engineers Fig. 1), the planet pinions (4) serve as balance levers between output gears (5&6). The teeth have an involute profile; the normals to the profiles at all points of contact pass through the pitch points, so the lever arms always remain equal: thus the differential is always in balance.

B. Planetary or epicyclic gear train: (Fixed Differential)———Engineers Fig. 1&2— Like and/or similar to pg. 3.30 Fig. 3.24 Dudley's Gear Handbook—Table 3.9 Pg 3.29 covers fixed differential gear data.

The planetary or epicyclic gear train gets its name from the resemblance to our solar system. A planetary gear set always includes a sun gear (9&10), one or more planet gears (11), and a planet carrier or arm (12) as shown in (Engineers Fig. 2). Fundamentally, a planetary is a special type of epicyclic gear train in which one of the axes of gears may be in motion. The gear train discussed herein may be either simple or compound depending on the configuration of the planet member itself. If the planet gear has two different gear faces, it is said to be a compound planetary. The theory of operation of the two types is the same, but generally the compound type is used for larger reduction ratios. Planetaries can be used in the design of computing mechanisms to predict a single output by summing two inputs to provide a single output.

A planetary gear set has two degrees of freedom. This means that the motion of each element of the mechanism is not defined unless the motion of two of its elements is specified. The important feature here is that the output is always the function of two inputs. During operation the inputs sometimes operate as outputs and outputs sometimes operate as inputs as in the case of an overrunning condition where the vehicle wheels are being driven instead of doing the driving (such as engine braking, in such cases there may be torque reversals

within the system without changes in direction of rotation.)

Combined assembly —Automatic Variable Ratio Differential (Further described and named in Section One)

The invention described herein uses a planetary gear set applied to each of the output shafts of a differential. Further, the two planet carriers of the planetaries are driven by the planet carrier of the differential device previously described. They may be directly coupled (as in the case described here) or gear-driven from the main differential carrier. The point being that there is a direct and constant relationship between the motions of all the planet carriers.

Another very important feature of this system is the "ground-link". The ground-link connects the two output shafts of the planetary (see Engineers Fig. 3). This connection provides a mechanical communication link between the two drive wheels, back through the planetaries, and ultimately back to the balancing planet pinion (4). With this information the differential can decide mechanically which wheel to send the torque to. This mechanical decision making process happens continually, rapidly, and without interruption. It is basically an analog input (acting through the ground-link that exists between the two wheels) that makes the system perform the way it does. The analog input varies instantaneously with the turning radius that each wheel is experiencing.

Caster Steering System

(Load Axle Steering by use of Torque Reversal)

2/12/98--To be understood with E-Drawing 9C

It has come to my attention that the steering system described in drawing 13 and text (E-Drawing 9C) requires a turning mechanism which can emulate a caster when the reversal of the inside wheel causes the instant center to move to a point between the vehicle wheels Drawing 14 Fig. 2 Point J from a point outside the vehicle wheels Drawing 14 Fig. 1 Point I.

It is probably impossible for a vehicle with a wheel base twice the length of the 1/2 axle Drawing 14 Fig. 1 & 2 Lines L & M, using a conventional steering system in conjunction with an open differential which scribes about an instant center (such as Drawing 14 Fig. 1 Point I) to move the instant center of its turn to Drawing 14 Fig. 1 Point K and perform a turn wherein:

The inside wheel stops.

The instant center (the point about which a body/vehicle tends to pivot or turn) moves to the center of the inside wheel Drawing 14 Fig. 1 Point K.

This is because some of the forces acting to cause a turn are in conflict with each other as stated in the explanations of drawing 13 (E- Drawing 9C - Fork-lift Advantages page 21).

However, by using the Reversing AVRD it becomes possible to move the instant center past Drawing 14 Fig. 1 Point K to a point between the vehicle wheels Drawing 14 Fig. 2 Point J because the two driving wheel forces compliment each other when the inside wheel reverses.

To accommodate this maneuver (load axle steering by use of torque reversal) a single (controlled) steering caster with the ability to turn more than 180 degrees becomes necessary or with two steering tires a turning system can be designed which traces the tangents of circles Drawing 14 Fig. 2 Point J 3 and J4 based on the changing instant center.

How to find an instant center and planetary set ratio to best accommodate it. Example:

The instant center of a vehicle is suggested by the ratio of the 1/2 axle length divided into the wheel base. When the half axle is 3 1/3' and the wheel base is 16' (5 : 1) a ratio of 2:1 is suggested for the planetary sets of E-Drawing 9C to place the instant center of the vehicle at a point 1/5 of 3 1/3' = 8" inside the inside wheel with the planetary set brake fully applied. This is because the 2:1 ratio in 9C creates a -.5 reverse rotation of the inside wheel and +2.5 rotation of the outside wheel (5 : 1) per revolution of the open differential carrier.

Note the ratio of the wheel speeds (5: 1) are the same as the ratio of the 1/2 axle divided into the wheel base (5 :1) and therefore complimentary. These ratios in the differential and the planetary sets can be customized, modified etc. to a range of vehicle configurations.

A computer chip and lineal positioning hydraulic cylinder set up to turn a multiplying device such as Drawing 14 Fig. 3 & 4 in which 3 A & B are a set of gears, sprockets and linkages etc. designed to multiply the rotational stroke of a lineal positioning or other Computer Numerical Controllable (CNC) device used at the top of caster Fig. 4 D comes to mind as an example of many ways to accomplish the desired purpose of reducing the turning radius of any vehicle and accommodating this maneuver by turning like a caster in response to a three point ground link.

Drawing 15 High Speed Applications

Automatic Variable Ratio Differential (AVRD) Brake and/or Automatically Controls the Turning Radius of a Vehicle and Coordinates the Tire Speed

One version of a device designed to compliment automatic inside wheel reverse Drawing 9B and cause the inside wheel to slow thus creating a turning circle is created by adding brakes attached to the two Double Star Planetary carriers shown at Drawing 15 Item 29&30–31&32.

Drawing 15—An (AVRD) such as Drawing 15 is created wherein :

1. The axles (10 &11) are connected to the annular gears (15 & 16) of the planetary sets. Drawing 15

2. The shafts (Drawing 15 Items 27 & 28) from the side bevel gears of the open differential connect to the planetary carrier of the Double planetary sets. Dwg 15 Items 17&18 This arrangements slows the two wheels when a brake is applied, the brake side is slowed most.

3. The 2 sun gears are rigidly attached to the open differential carrier (at 25&26) and are hollow to allow passage of the shaft connecting the side bevel gears to the 2 planetary set carriers. Drawing 15 Points 25 & 26

This creates a device that breaks up in a turn to be A forward motion slow down (Reduction) on the inside axle, and a Forward overdrive on the outside.

Since the inside wheel experiences reduction when its' brake is held and the outside wheel experiences overdrive, the vehicle turns around an instant center outside the frame. Variations of planetary set ratios can be custom configured to move the pivot point of the vehicle from place to place in the radius of the turn.

The ground link connection in this device which will have 3 points because of the influence of the steering axle (point 3). That is to say, The two driven wheels will be allowed to input to the system only as the steering axle allows in terms of the forward radius and the reverse radius allowed by the steerage moving out of the way and to the side of the reversing driver. To be understood the vehicle should be thought of as two one wheel drives (similar to individual hydraulic motors on each wheel, with independent control) and then combined. Either driving wheel would provide motivation to the vehicle, this system allows the best of forward propulsion in a turn. The addition of a brake assembly at Drawing 15 Item 29/30 & 31/32 gives the system operator control by a joy stick or other device on a vehicle. The system is mechanically coordinated to reduce ground deformation. This system is suited for higher speed applications.

Drawing 16--Preferred Device

Automatic Variable Ratio Differential (AVRD) Designed to Use Planetary Sets (Drawing 10) To Produce Aggressive and/or Creeping Effect

Drawing 16 — One version of a device designed to cause aggressive behavior

An (AVRD) such as Drawing 16 is created wherein :

1. The differential carrier (12) is connected to the planetary carrier of the planetary set cluster (5 & 6).

Drawing 16 Items 12, 5 & 6

2. The shafts 27 & 28 (Drawing 16) from the side bevel gears of the open differential connect to the sun gears 2 & 3 of the planetary sets.

Drawing 16 Items 1, 27, 28, 2 & 3

3. The pair of annular gears are rigidly attached to the output axles 10 & 11.

Drawing 16 Items 10, 11, 15 & 16

This creates a device that breaks up in a turn or spin out (Bog) situation to be like Drawing 10 Item 4 (Minimum Over Drive) on the stopped axle, and like Drawing 10 Item 1 (Maximum Reduction) on the spinning axle. It is important to remember these are mirrors to each other when attached to the opposite ends of the open differential and stationary is relative in terms of least resistance, therefore Drawing 10 Item 1&4 swap sides and dominance constantly according to ground link conditions.

Since Drawing 10 Item 1 is a Maximum Reduction and Drawing 10 Item 4 is a Minimum Over Drive, the path of least resistance tries to follow the wheel with traction. Horsepower circulates in the system and the path of least resistance changes constantly as the planetary sets adumbrate from (Drawing 10 Item 1 to Item 4) configuration and the system searches for a place to use horsepower efficiently.

This device addresses the same or similar circumstances as described in B. & C. and most descriptions may be considered cumulative. By variation of the base ratio in the two planetary sets the device can show qualities of both Aggressive and Creeping AVRDs.

Custom designs of similar nature can be created by the designs suggested by Photo #1 and all versions including the A, AA, B, C, Drawing 10 etc. can oppose each other effectively through any open differential or conventional limited slip differential.

William D. and Richard Rogers Co-Inventors 9/1/97

Drawing 17 Transmission

Automatic Variable Ratio Transmission (AVRT) Designed to Use Planetary Sets (Drawing 10) To Produce Forward, Reverse, and Nuetral Without Shifting gear Engagement or Hydraulics Uses Unique, one piece internal carrier Which has Other Applications

One version of a device designed to produce Forward, Nuetral and Reverseis created by adding brake/clutches

Drawing 17—An (AVRT) such as Drawing 17 is created wherein :

1. The output (10) is connected to the annular gear (15) of the planetary set. Drawing 17

2. The one piece rotary input/carrier/shaft (Drawing 17 Item 12A) connects to the sun gear (2) . Dwg 17 Items 12A & 2. This arrangement produces reverse rotation (counter to input) of output 10 when brake (31 & 32) is applied.

3. The carrier shaft 12A passes completely through the transmission and connects to annular gear 16 by way of carrier cross 12B and carrier connection 12C thuss driving said annular 16 at all times.

4. Sun gear 3 is free to stand or spin on 12A.

5. When both brakes (29 & 30--31 & 32) are free, the output 10 is in nuetral and produces niether torque or rotation.

6. When brake 29 is held by shoe 30, torque from 16 drives planet gears 4 which is attached to side bevel gear 1A. The open differential drives planet gears 5 faster than sun gear 2 and forward output torque results at output 10.

7. When both brakes are held the transmission is in lock down stop as is true of all these devices here described.

8. Additional components may be added to produce multiple ratios.

Drawing 18 PLTA

Automatic Variable Ratio Differential (AVRD) Brake and/or Automatically Reduces the Turning Radius of a Vehicle

One version of a device designed to compliment automatic inside wheel reverse Drawing 9B and cause the inside wheel to reverse thus creating a reduced turning circle is created by adding brakes attached to the two Star Planetary carriers shown at Drawing 18 Item 29&30--31&32.

Drawing 18—An (AVRD) such as Drawing 9C is created wherein :

1. The tire hubs are connected to the annular gear hubs of the planetary sets as final drive outputs. Drawing 18 Items 16 & 15

2. The shafts (Drawing 18 Items 27 & 28) from the side bevel gears 1A & 1B of the open differential connect to the planetary carrier of the planetary sets (Dwg 18 Items 4 & 5) and to brake assemblies(29&30 31&32), then continue beyond in one piece to support the tire hub output bearings.

3. The 2 sun gears 3 & 2 are rigidly attached to the open differential carrier by tubular axles 12A & 12B which are hollow to allow passage of the shafts 27 & 28. Drawing 18 Points 12A & 12B

This creates a device that breaks up in a turn to be like Drawing 10 Item 3 (Reverse Reduction) on the inside axle, and like Drawing 10 Item 4 (Minimum Overdrive) on the outside. It is important to remember these are mirrors to each other when attached to the opposite ends of the open differential and stationary is relative in terms of least resistance.

Since Drawing 10 Item 3 is a reverse reduction and Drawing 10 Item 4 is a forward overdrive, the path of least resistance tries to reverse the inside wheel even as the outside wheel speeds around the turn. The result is a reduced resistance to the turning radius of the vehicle. Variations of planetary set ratios can be custom configured to move the instant center of the vehicle from place to place in the radius of the turn as required by pallet rack spacing etc. Thus increasing effective storage space.

The ground link connection in this device which will have 3 points because of the influence of the steering axle (point 3) which is an additional input to the system from the horizontal plane. That is to say, The two driven wheels will be allowed to input to the system only as the steering axle allows, in terms of the forward radius and the reverse radius allowed by the steerage moving out of the way and to the side of the reversing driver.

The addition of a brake assembly at Drawing 18 Item 29/30 & 31/32 gives the system operator control of inside wheel counter rotation which is induced by a joy stick or other device on a vehicle such as a bulldozer, zero turn radius mower, or other skid steering device.

Drawing 19/20

(Drawing 18 Plus Dual Inside Wheel Reverse Attachments)

Drawing 18 continued to become--Drawing 19

Automatic Variable Ratio Differential (AVRD) Brake and/or Automatically Reduces the Turning Radius of a Vehicle and Produces Independent 4 wheel Drive on one Dual Wheel Axle with Dual Inside Wheel Reverse in a Turn

One version of a device designed to compliment automatic inside wheel reverse Drawing 18 and cause the inside wheels of duals to be independently control reversed thus creating a reduced turning circle is created by adding a second pair of planetary sets as in Drawing 19

See Drawing 18 for explanation of the first two outputs 15 & 16

Drawing 19—An (AVRD) similar to Drawing 18 is created wherein :

1. The annular gear hubs 15 & 16 are connected to the planetary set cluster of the second or outside planetary set 4* & 5* by tubular axle/housing 12C & 12D. Drawing 19

2. The shafts (Drawing 19 Items 27L & 28L) from the side bevel gears 1A & 1B of the open differential connect to the planetary carrier of the planetary sets (Dwg 18 Items 4 & 5) and to brake assemblies(29&30 31&32), then continue beyond in one piece to support the tire hub output bearings, then continue out to attach to sun gear 3* & 2* and on to support the bearings of outer dual tire hubs which rest on the hubs of annulars 16* & 16*.

This creates a device that breaks up in a left turn (Brake 30 restrained by shoe 29 to be like Drawing 10 Item 3 (Reverse Reduction) on the inboard (Tire A) (counter rotating) axle of a left turn, and like Drawing 10 Item 4 (Minimum Overdrive) on the second (Tire C), even faster counter rotating wheel.

Tire B of drawing 19 reacts as in explanation 18 tire B in a left turn.

Meanwhile the out most dual (Tire C) moves faster than all other wheels and in the same direction of rotation as the differential carrier because it experiences the effect of (Drawing 10 Item 4) Minimum Overdrive induced by planet cluster 4B.

A right turn is executed by restraining brake 32 with shoe 31.

Thus is produced a device capable of acting in a turn to produce fast counter rotation of the inner most wheel of a set of duals (Tire C) executing a left (or right) turn, proper and slower rotation of the inboard inside wheel (Tire A), forward rotation of the outer inboard dual (Tire B) and faster forward rotation of the outer most wheel (Tire D). All wheels (Tires CABD) can be timed and coordinated to wheel spacing by proper planetary set ratios.

A Robotic Mowing Device

1. A program Computer Numerical Controlled AVRD can be built to operate on Solar Cell and Rechargable Batteries. A reciprocating (Hedge Clipper Type Blade) diagonal across the device at proper ground clearance would cut grass in ultra slow motion.
2. A track or caster type vehiclewould be used and the AVRD controlled by the computer. The vehicle slowly and constantly twirls about an instantant center changed by alternating the steering brake which is held or released to manuever about the program any unusual resistance would cause the system to adjust or change the motion but return to the program.

Bill Rogers 9/1/98

Bill Rogers

SUMMARY 9/1/98

RAVRD--Reversing Automatic Variable Ratio Differential --ZTR Turning Couple
AVRD--Automatic Variable Ratio Differential -- Positively Traction
AVRDT--Automatic Variable Ratio Transmission -- Automatic Transmission
AVRTC--Automatic Variable Ratio Transfer Case -- 4X4 Transfer Case
AVRD4x4--Four Wheel Drive on one axle--For very large dual wheel vehicles
AVRDDP-- Double Planetary AVRD--For Non-Reversing High Speed Vehicles

Normally a differential is considered to be a device which splits one rotary input into two variable speed outputs. We recognized the fact that the differential carrier is a pair of constant speed outputs and the differential axle is two variable outputs.

All AVRD's vary their output ratio by attachment of the the constant carrier speed of an open differential each to an input of two planetary sets and the open differentials variable outputs are used to drive the second input of the said pair of planetary sets, one planetary set is attached to these two outputs (by two connections) one on each side of the said open differential. The result is an interdependent phase shifting variable ratio on each tire caused by the four inputs which merge into two, speed and torque sensing outputs which vary in ratio in response to ground link conditions with a mind bent upon forward motion. The number of combinations of this arrangement are staggering and likewise are the number of problems which can be addressed by custom designed solutions.

1. Our positive traction differentials and 4x4 transfer cases are all gears. They will be the only option for vehicles larger than 1 Ton Trucks etc. and a traction improvement for smaller vehicles.

2. Better traction from smaller tires mean the mast of an all terrain fork-lift can be closer to the vehicle center of balance with corresponding reduction of size, weight, and cost as maneuverability and traction improves.

3. The transmission version will seek efficiency by variation of ratio, effectively finding the right gear ratio to make best use of the least possible fuel. There are also other reasons for efficiencies. We have built and tested a version with forward, reverse and neutral as in the video.

4. My tentative examination of a question by an interested party, tells me the device will produce a drive mechanism with four outputs from one input or an independent drive for each tire of large dual wheel vehicles which now leave a sheet of rubber, from a very expensive set of tires, on the deformed ground each time they execute a turn.

5. The Positively Traction feature of the Reversing Automatic Variable Ratio Differential (RAVRD) is all gears. Unlike friction or inefficiency based devices such as are used in other limited slip differentials. Therefore, the AVRD is traction compatible with a quick turning radius and operates throughout the turn.

6. There is a chronic need for a small and large positive traction differential with inside wheel reverse for all terrain. We believe the (RAVRD) will help deal with traction problems on an all terrain mower due to its Positively Traction feature, a feature which operates even while a turn is being executed. The Reversing Wheel features', reduction of turning radius, further improves the vehicle for better utility value.

These facts will reduce the gross weight of ZTR mowers by eliminating:

A. Two hydraulic pumps
B. Two hydraulic motors
C. Two hydraulic reservoirs
D. Two sets of lines
E. Two oil supplies, filters etc.
F. One reduction gear train
G. Two sets of hydraulic valves
H. Hydraulic pressure, heat build up, or oil breakdown.

(2)

7. In the same breath it will increase efficiency to the 95% of gears versus 50% efficiency of hydraulics. This efficiency when combined with the above weight reductions will reduce engine size, fuel consumption, and wear and tear of the afore mentioned unnecessary parts.

There is no hydraulic oil, or oil pressure, to create ecology problems and the efficiency of gears is a win win scenario. Grit and foreign matter become a small problem in this all mechanical device when it is compared to hydraulic pumps, valves, and motors.

There are also available as features of the RAVRD (Reversing Automatic Variable Ratio Differential) the following qualities which further compliment the above mentioned features:

1. Inside wheel reverse, which provides proportioned reversal of torque on one wheel even while the rotation of that wheel continues forward; and, when counter - rotation occurs the reverse is proportioned. Base ratios can be customized to finish a turn exactly next to the last pass, not over the last pass or inefficiently; with less dependence on operator skill.

Tire wear is reduced and ground scalping caused by the tires is reduced to a minimum or eliminated due to the coordinated synergistic operation of the gear system.

A couple is a perfect way of turning

It consist of two forces of equal magnitude in parallel but oppositely directed.

The RAVRD is a perfect couple.

A couple facilitates a turn from dead stop. No forward motion of the vehicle is required.

Conventional steering is like pulling a tap with two hands on the same side of the tap wrench, our couple is two coordinated hands with built in skill used on both sides of a proper tap wrench.

The about face of the RAVRD is gear coordinated to place the mower exactly on the next cutting pass every time, as illustrated in the accompanying video!

2. Multiple paths of least resistance and variable ratios controlled perfectly by the ground link, lengthens the stress interval of internal parts to minimize torque shock.

3. An instant center near the inside tire is better because the turn aligns the vehicle for the next pass. An instant center dependent upon operator skill will not be perfectly offset to one side of the last pass, after a maneuver.

4. Our device has the ability to reverse torque before the inside tire actually reverses rotation. This will help in a turn even when conventional steering is used and do less damage to the ground under any circumstances. The RAVRD perfectly reduces turning radius to a point inside the frame, even from a dead stop.

5. It is very important to remember our traction feature and limited ground deformation, even on wet days, will allow the commercial mower operator or the homeowner to work when he otherwise could not. Also, some of those damp days are cooler.

6. There is practically no limit to how large or small this device can be built, in terms of size or horsepower, since it is all gears. Plastic toys or huge bull dozers come to mind.

7. The brakes are in the hands of the operator at all times, since application of both steering brakes at once locks down the system.

8. It is important to understand: (See Drawing 9C & 10)

The traction feature is produced by the influence of the ground link changing the nature of the system, this can be best analyzed by an extreme; that is by realizing what happens to the planetary sets illustrated in Drawing 9C (the quick turn device differential) when the brake is held. <u>The nature of the planetary sets change, therefore horsepower is not sacrificed or heat built up at unacceptable levels.</u> The planetary set with the brake held (inside wheel of a turn) isolates to become (see Drawing 10 Item 3) reverse reduction and is driven only by the sun gear (3). In this instance it produces 1/2 the speed of the carrier in reverse. Infinite custom ratios to move the vehicle <u>instant center</u> are practical, however.

The outside wheel receives forward rotation at twice the speed of the carrier from the 2:1 over drive in the open differential, plus 1/2 the speed of the carrier from the rotational input produced by the sun gear (1B). This is because the brake holds both the planetary cluster (4) and the side bevel gear (1A).

Therefore, holding the brake does not overpower the sides of the system, instead, the components change their nature. <u>The minus 1/2 revolution which is taken from the inside wheel is given back by a plus 1/2 revolution added to the 2 revolutions of the outside</u>

wheel for a total of 2 1/2 revolutions of forward per revolution of the differential carrier.

Note:

The faster out put axle (11) is now driven by the carrier sun gear (3) and the side bevel gear axle (28). This changeling nature is evident throughout the operating range of the system and manifest as a variable ratio produced either by the ground link or the brake. Once outside wheel acceleration is satisfied the system returns to a balance similar to a straight forward, even though it is in a turn. The instant center of the vehicle is also the horsepower center of balance of a coordinated system.

Because a couple is a balanced change of system configuration and ratio, (the horsepower load of the drive tires of a couple are equal even though their speed and torque vary as the instant center changes) relatively little effort, friction, or heat build up occurs at the drum and shoe. In fact once a turn is fully deployed and the casters have found a pattern, it is often necessary to apply the opposite brake to change the turn.

Further more, a steering setup which emulates a caster pattern can produce counter rotation of the inside wheel in a turn, much the same as a brake.

9. Uses:

Skid steering loaders, six wheelers, wheel chairs, farm tractors, robots, fork-lifts, loaders, floor sweepers, lawnmowers, military vehicles, the retrofit market, recreation vehicles, toys and etc. The AVRD will make all of these more practical, efficacit, and efficient not to mention reductions of weight, cost, tire wear, operator fatigue, and ground deformation.

The resulting all mechanical device is more easily serviced, by less skilled and trained personnel using simpler tools.

All these features combine to provide a market weapon other than price, although they are kind to the customers budget and the manufacturers bottom line. Such a weapon creates and defends profit.

What we claim is:

1. A rotary differential device, comprising:

a rotary input to an open differential carrier;

said carrier encompassing an open differential gearing;

said carrier rigidly attached to any of the 3 inputs of a pair of planetary sets, thus forming constant speed inputs to said planetary sets;

said open differentials side gears rigidly attached to the planetary clusters of said pair of planetary sets, thus forming variable speed inputs to said planetary sets;

output shafts (axles) attached to the remaining components of the planetary sets;

a restraining mechanism attached to the planetary clusters which is further attached to the differential gearing variable speed output members (side bevel gears);

individual restraint of said brake mechanisms produces reverse of the nearest related output and acceleration of the opposite extremity output;

restraint of both static inputs (brakes or rotary inputs) brakes the system;

(brake or clutch may be replaced by a rotary input);

such configurations when attached to drive tires of a vehicle offers traction and steering advantages as governed by the ground link inputs;

the results of the above influences of rotary and static inputs may be varied by sundry mix and match configurations and hook ups of the open differential and planetary sets to form;

Traction control devices, steering devices, 4x4 power dividers, (forward, reverse, neutral, multi-speed) transmissions, etc.;

Transmissions thus configured may include similar or dissimilar planetary set embodiments and or multiple planetary sets configured to produce efficacit results usually routed from one input to one output;

Traction steering and power divider devices usually have two outputs, but component stacking makes multiple outputs with multiple coordinated speeds possible even on the same axis from one constant input;

all of these devices offer infinitely variable ratio in each range of operation;

the result is a speed and torque sensing device which does for the open differential as much as the open differential does for a solid axle;

any open differential device may be used including conventional limited slip devices;

the carrier of said mechanisms may be internal or external or combinations of the two.

Open Differential

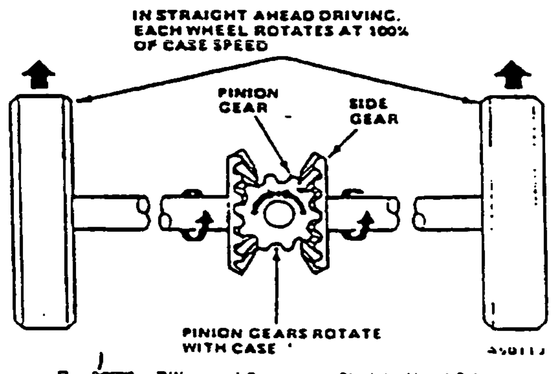


Fig. 1 Differential Operation—Straight Ahead Driving

DRAWING 1

2.

open Differential

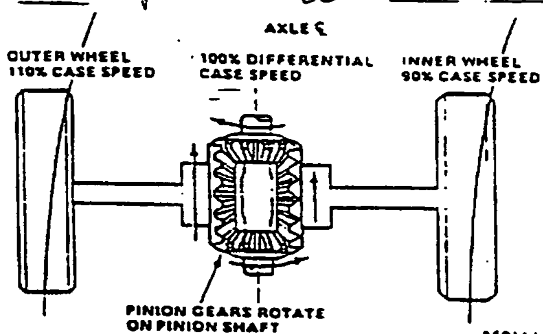
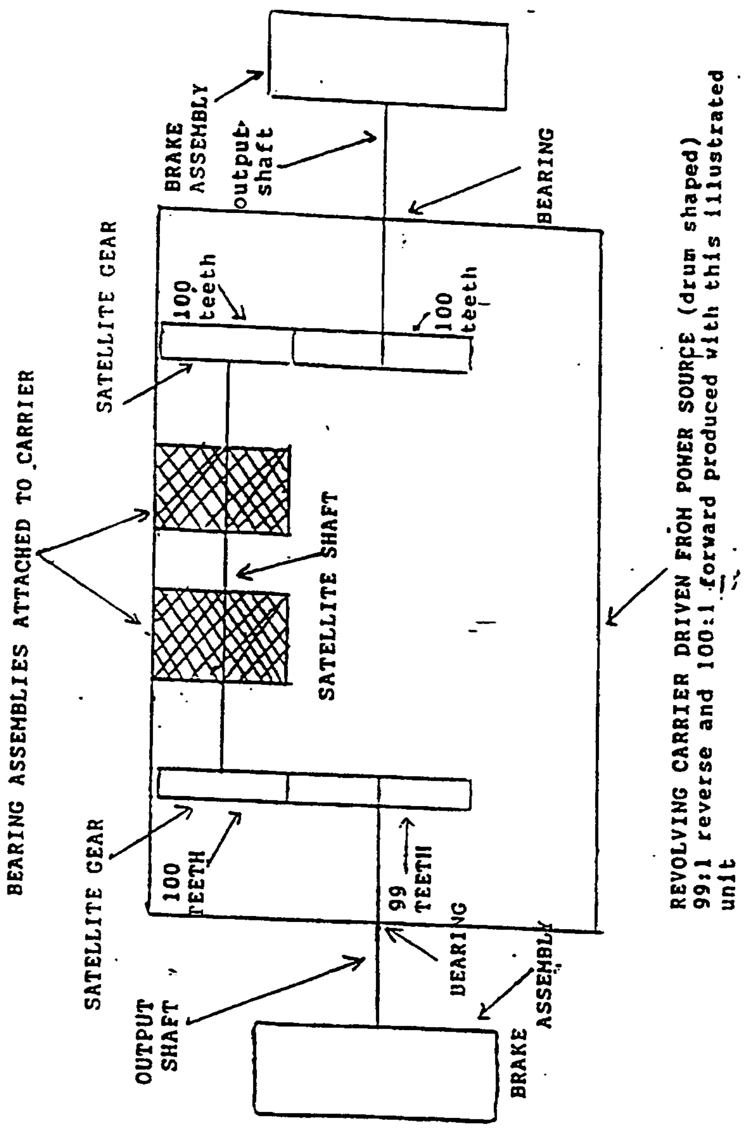
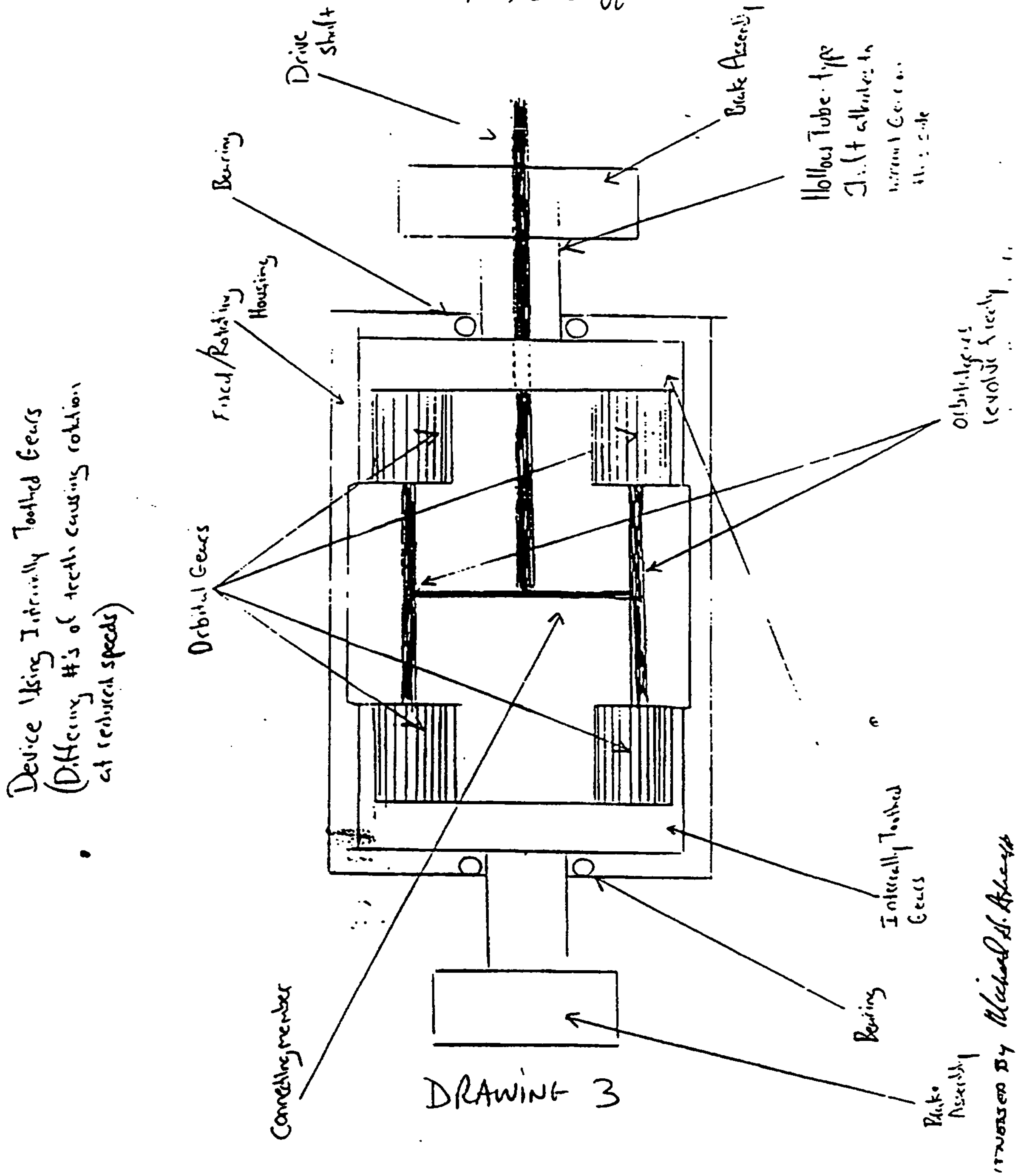


Fig. 2 Differential Operation—On Turns

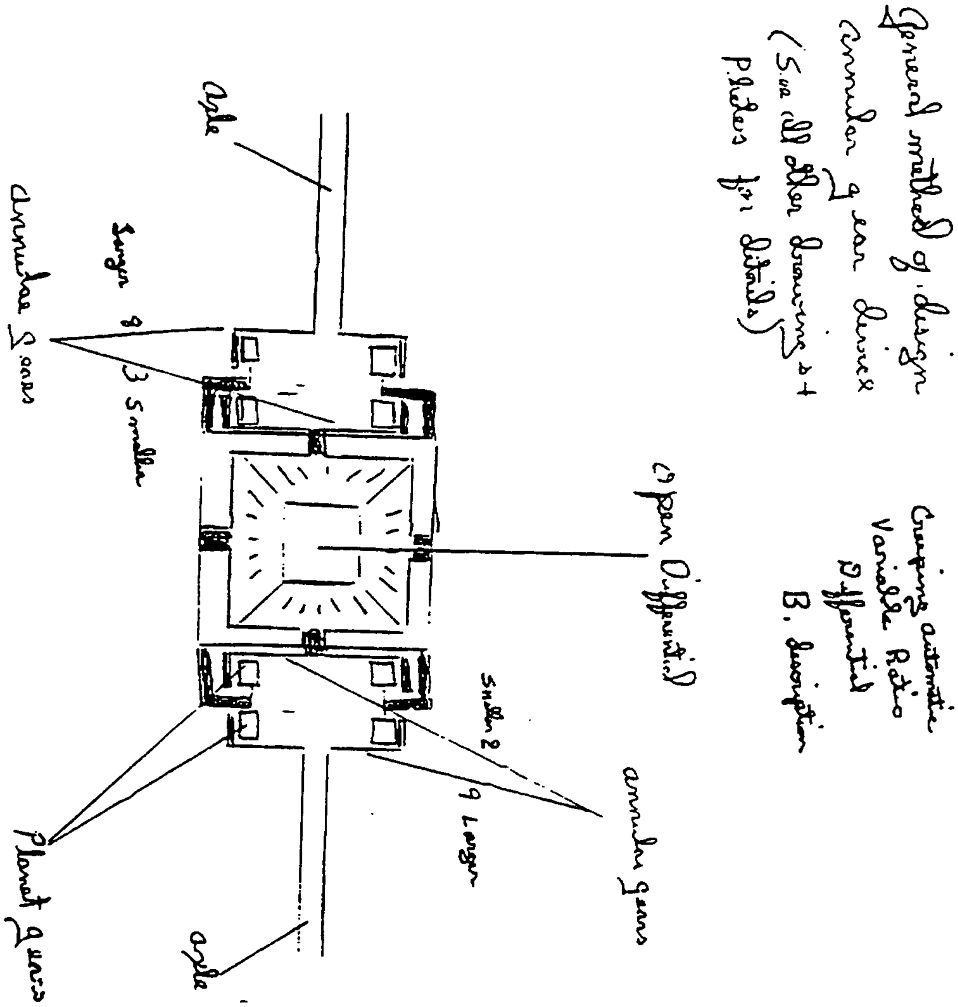

BEARING ASSEMBLIES ATTACHED TO CARRIER
SATELLITE GEAR
100 teeth
100 teeth
BRAKE ASSEMBLY
output shaft
BEARING
SATELLITE SHAFT
SATELLITE GEAR
100 TEETH
99 TEETH
SATELLITE GEAR
OUTPUT SHAFT
BEARING
BRAKE ASSEMBLY
REVOLVING CARRIER DRIVEN FROM POWER SOURCE (drum shaped)
99:1 reverse and 100:1 forward produced with this illustrated unit

DRAWING 2

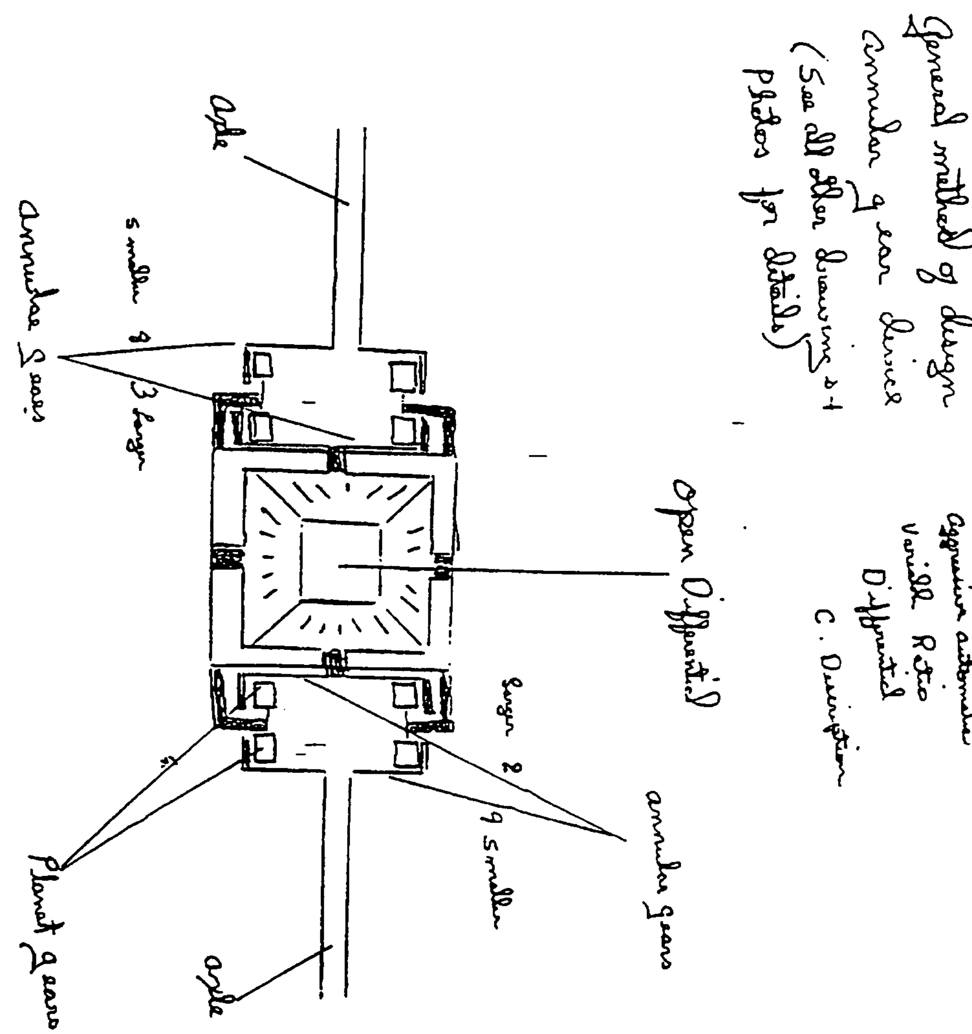
Annular Fixed Differential



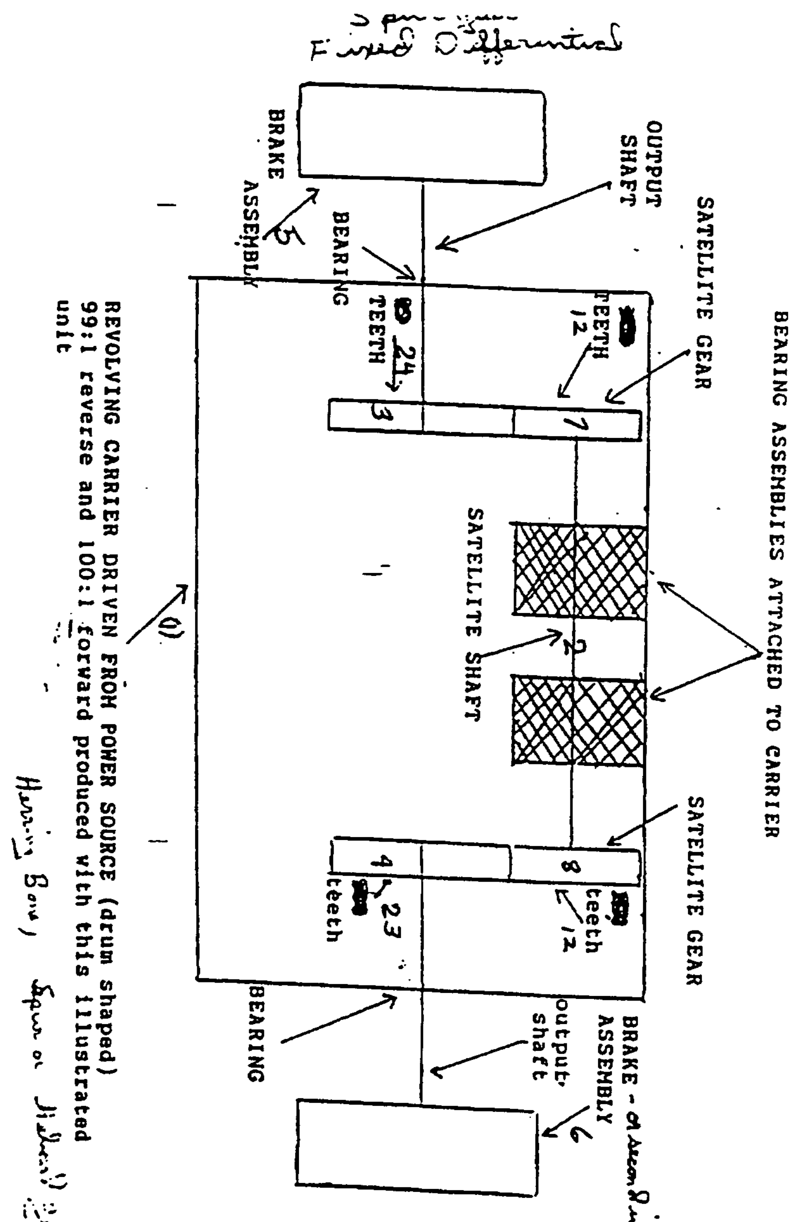
DRAWING 3



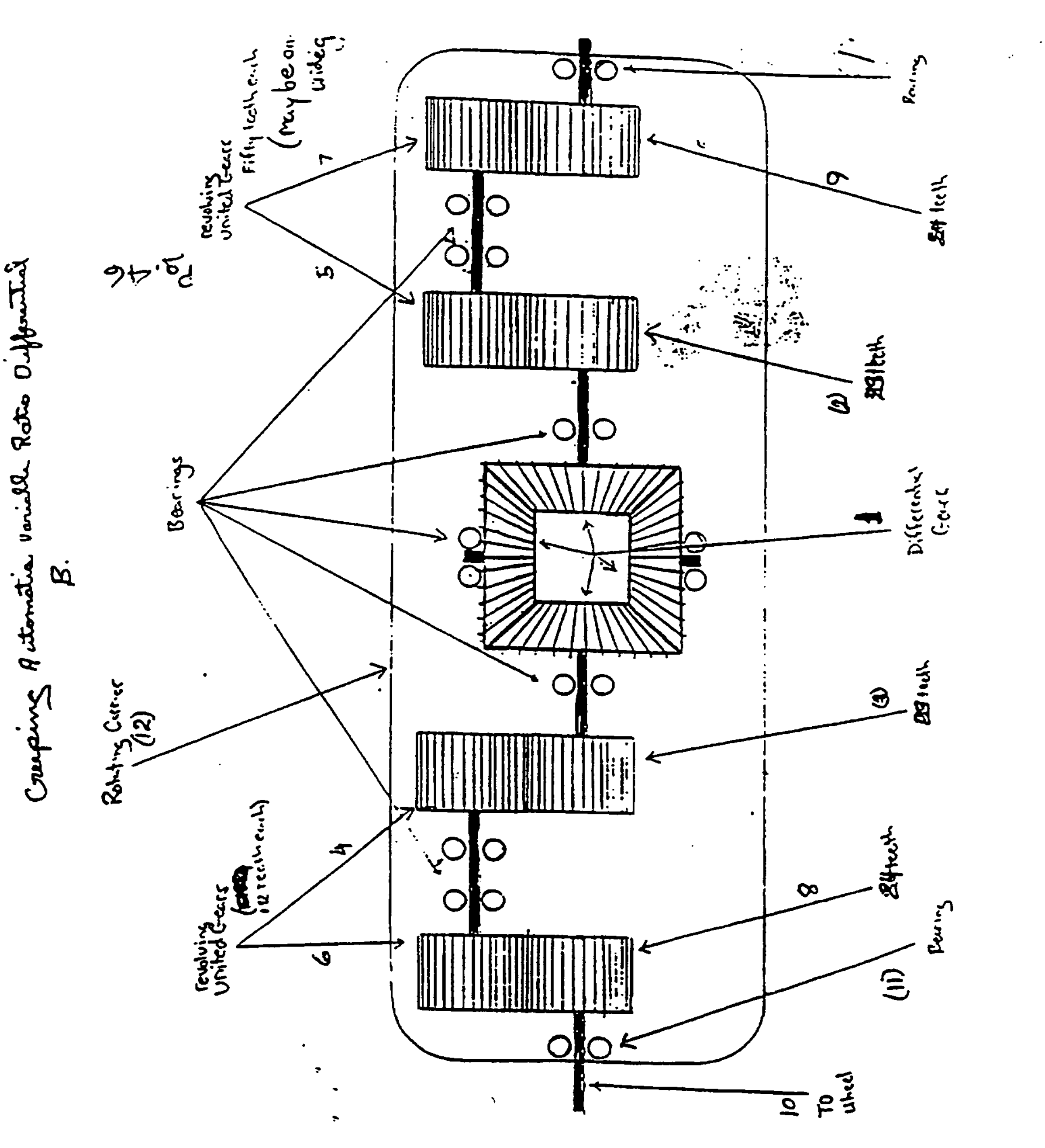
DRAWING 4A
4/45


General method of design annular gear device (See all other drawings & photos for details)
Aggressive automatic Variable Ratio Differential C. Description
Axle
smaller 9
3 larger
annular gears
Open Differential
larger 2
9 smaller
annular gears
Planet gears
axle

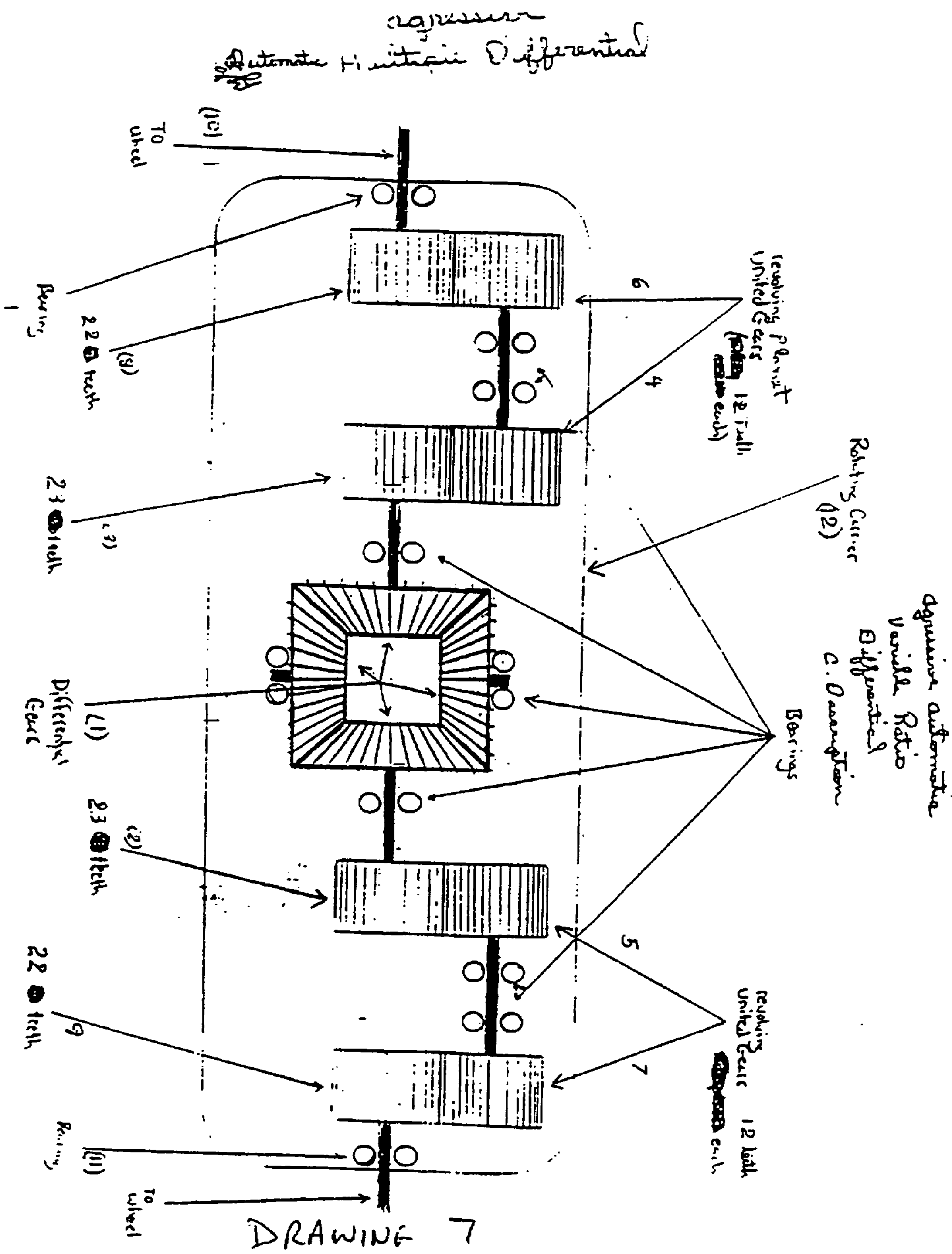
DRAWING 4B


Fixed Differential
OUTPUT SHAFT
BRAKE ASSEMBLY
5
BEARING
SATELLITE GEAR
BEARING ASSEMBLIES ATTACHED TO CARRIER
TEETH 12
24 TEETH
3
7
SATELLITE SHAFT
2
1
SATELLITE GEAR
8
4
12 teeth
23 teeth
BEARING
output shaft
BRAKE - or second input ASSEMBLY
6
REVOLVING CARRIER DRIVEN FROM POWER SOURCE (drum shaped)
99:1 reverse and 100:1 forward produced with this illustrated unit
Herring Bone, Spur or Helical

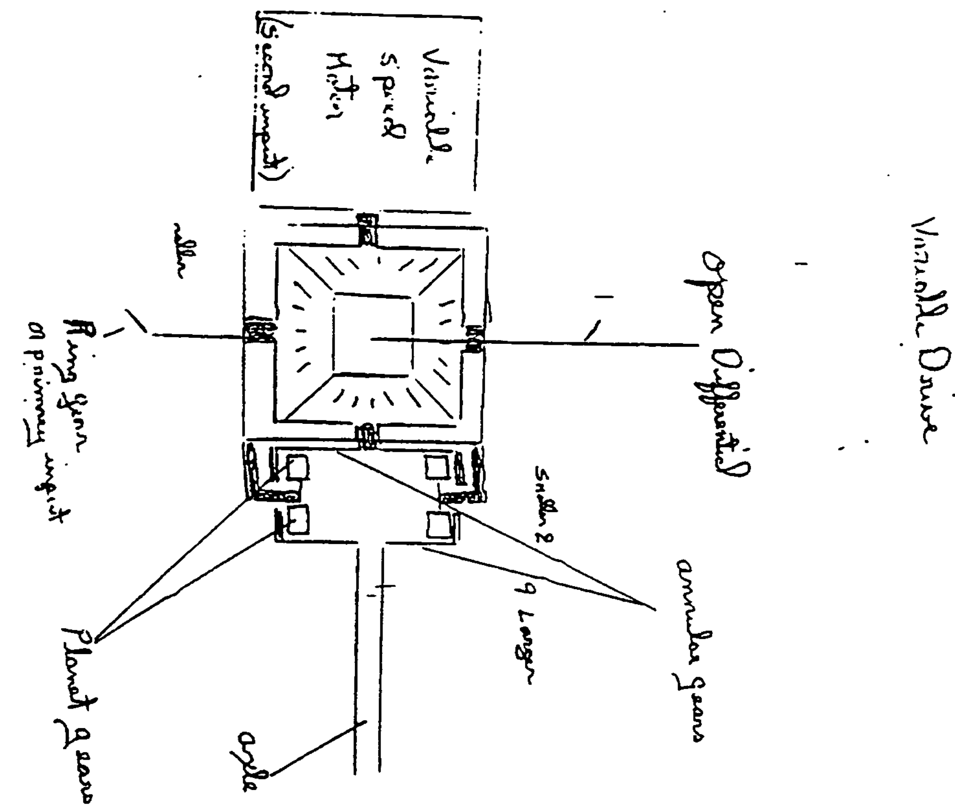
DRAWING 5


Creeping Automatic Variable Ratio Differential
B.
Bearings
Differential Gear
Rotating Carrier (12)
Revolving United Gears
Bearing
To wheel
10
24 teeth
8
9
(11)
6
4
5
7

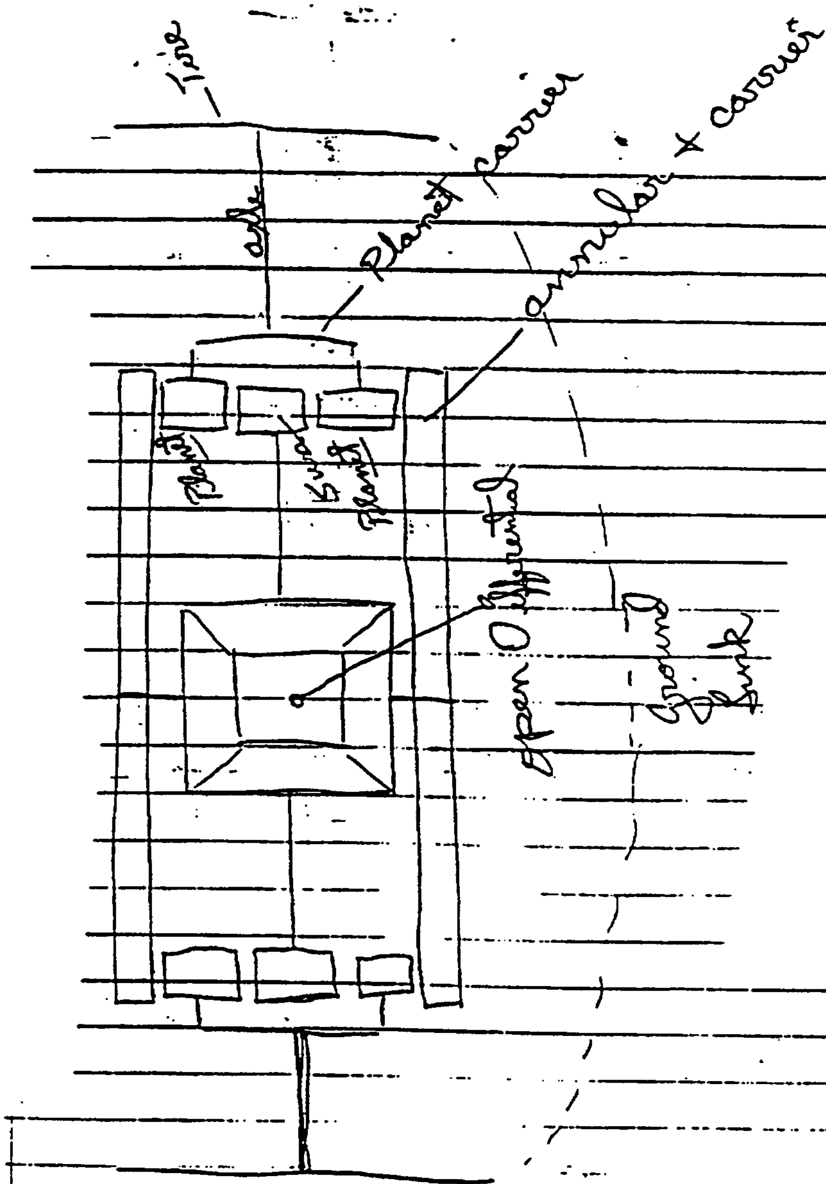
DRAWING 6


To wheel
Bearing
22 teeth
23 teeth
Differential Case
(1)
Rotating Carrier
(12)
Bearings
Variable Ratio
Differential
To wheel

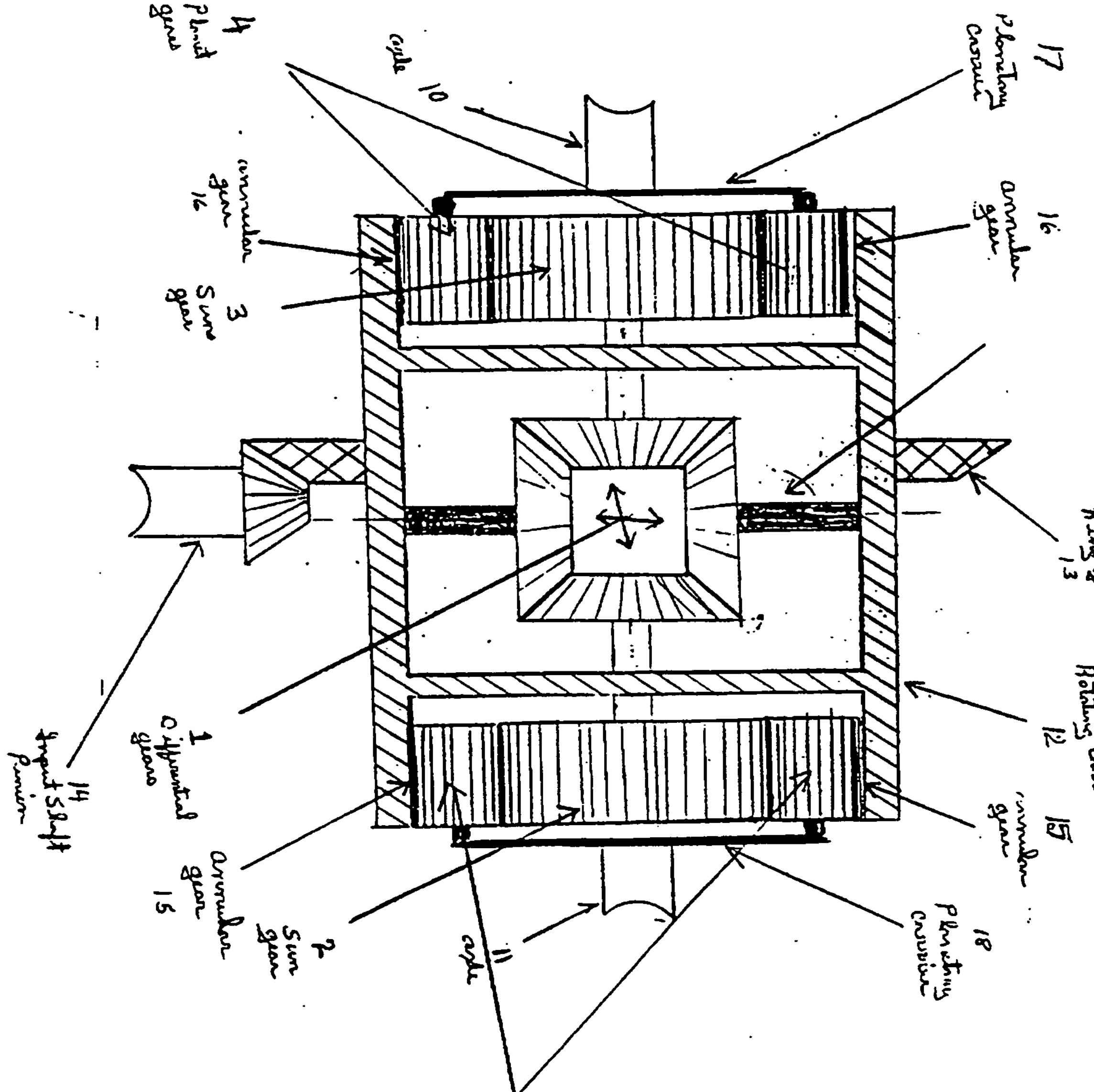
DRAWING 7



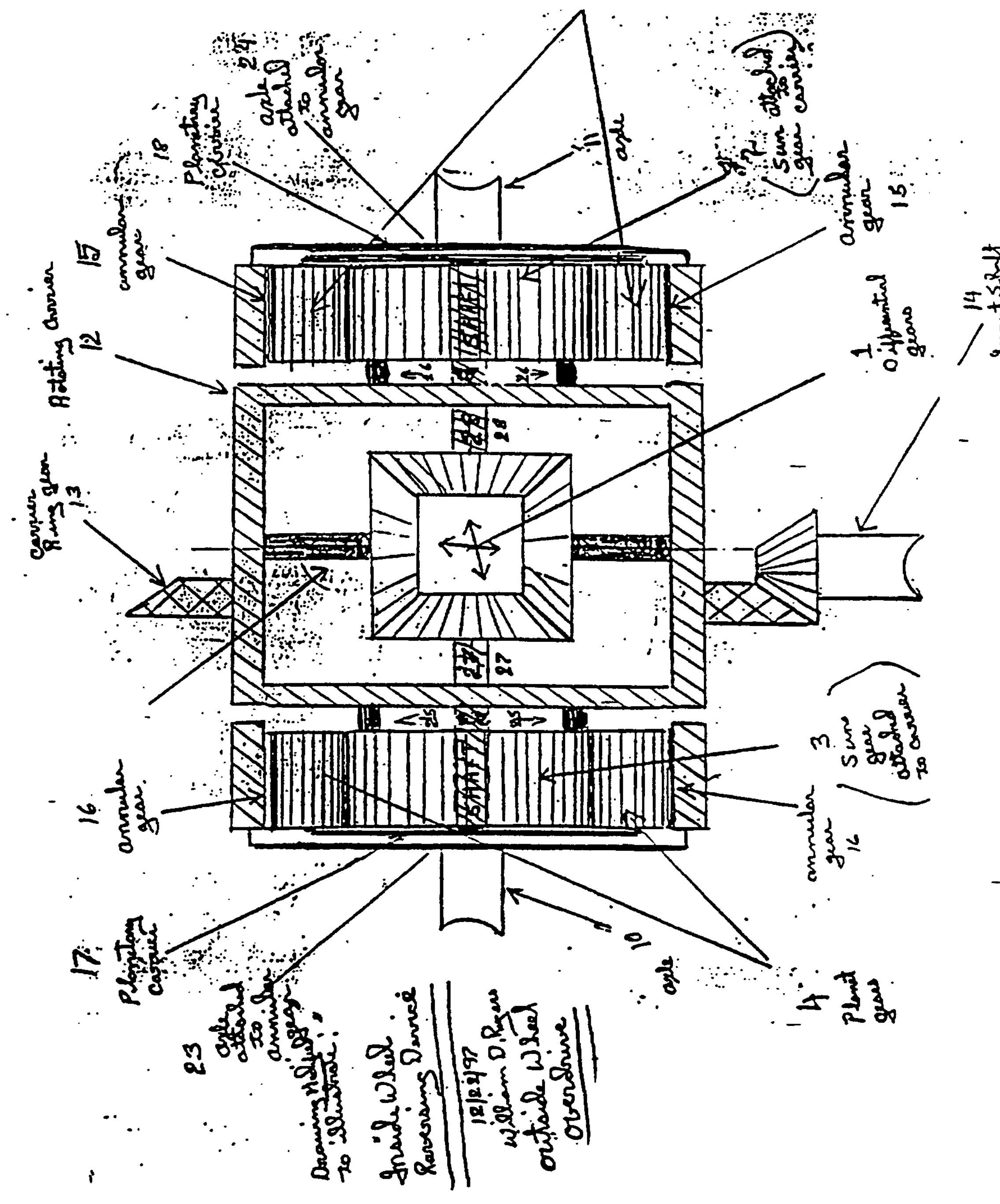
DRAWING 8


Tire
axle
Planet carrier
annular + carrier
Planet
Lwo of Planet
Planet
Open D differential
ground Link

DRAWINF 9A


4 Planet gears
axle 10
17 Planetary Carrier
annular gear 16
3 Sun gear
annular gear 16
Carrier Ring gear 13
Rotating Carrier 12
1 Differential gears
14 Input Shaft Pinion
annular gear 15
annular gear 15
2 Sun gear
11 axle
18 Planetary Carrier
5 Planet gear

DRAWING 9A-1


annular gear 15
Rotating carrier 12
Carrier Ring gear 13
annular gear 16
Planetary Carrier 17
axle 10
axle 11
Planet gears 4
Differential gears 1
Input Shaft Pinion 14
Sun gear attached to carrier 3
SHAFT

DRAWING 9B

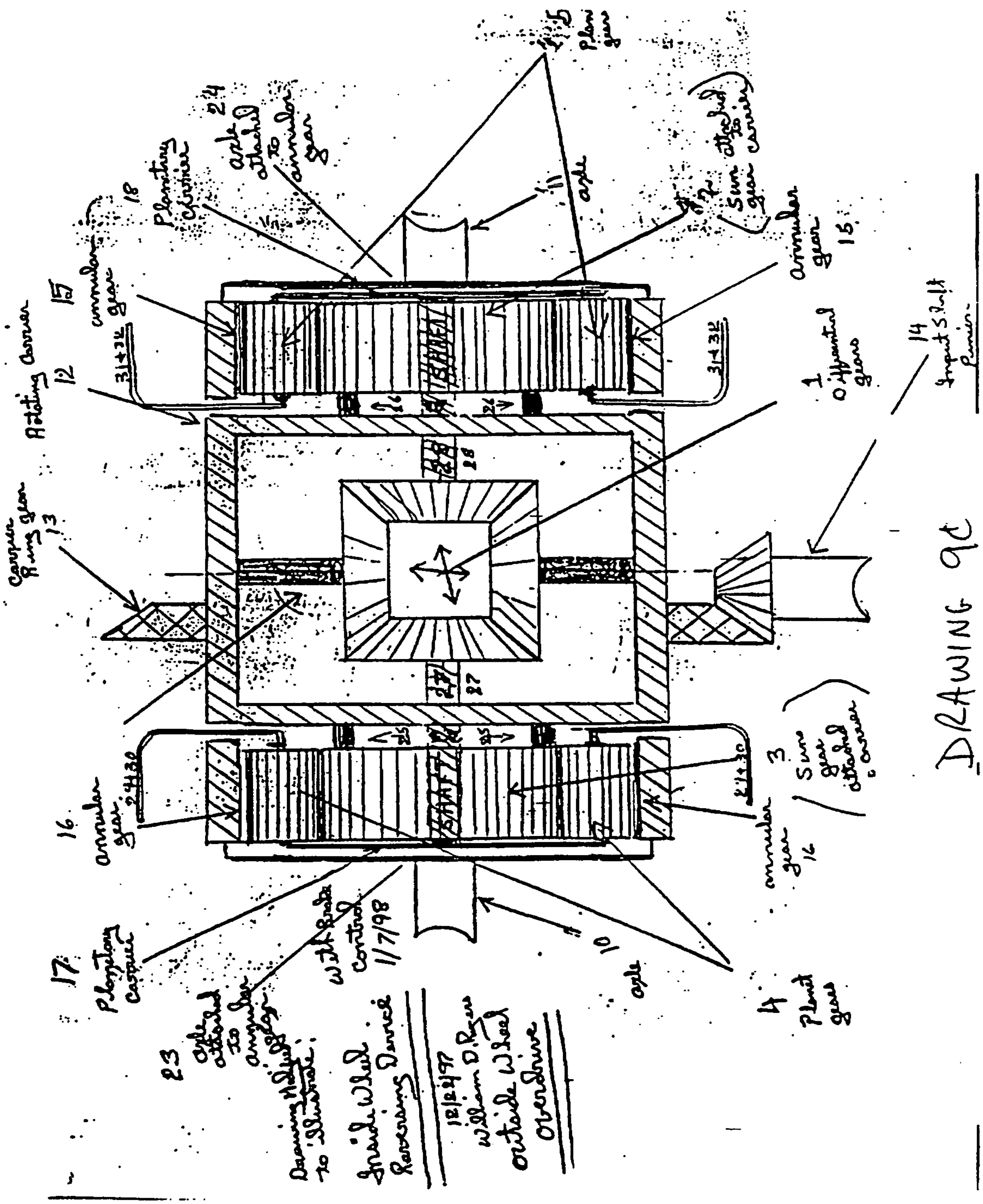
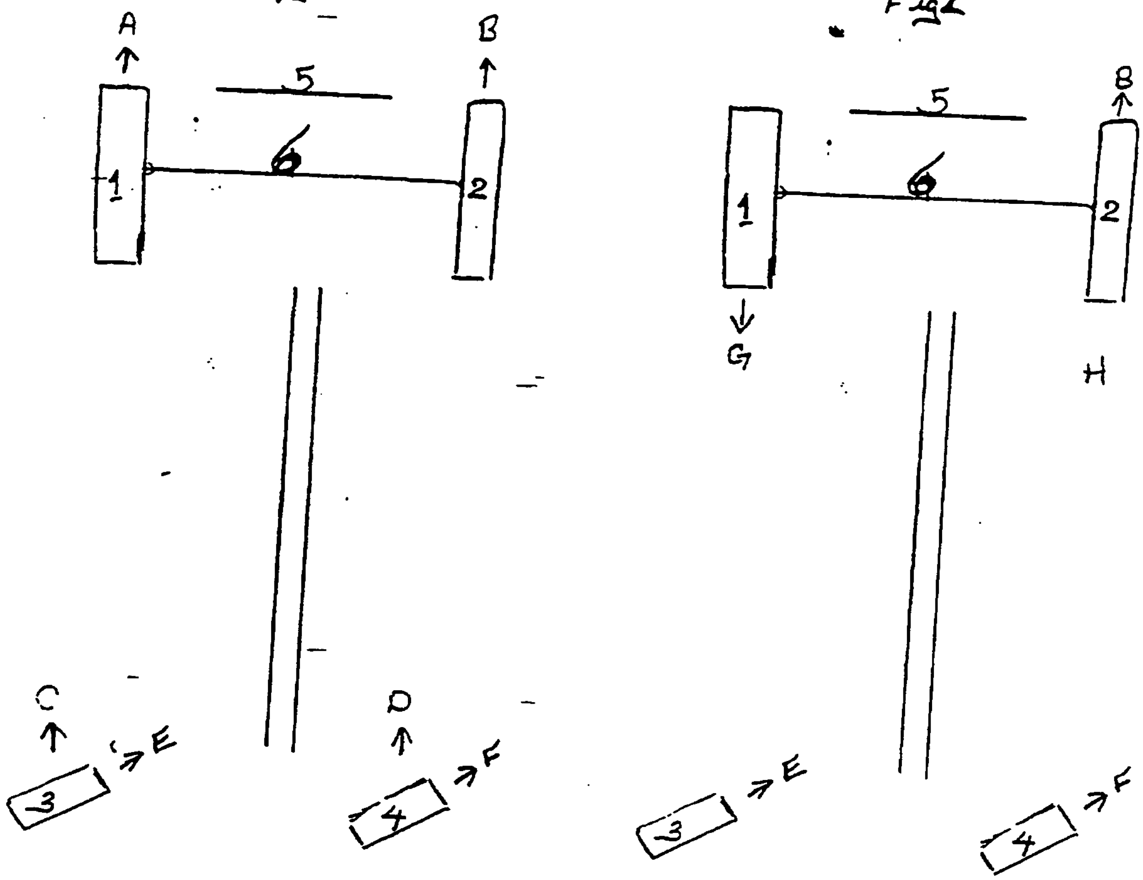
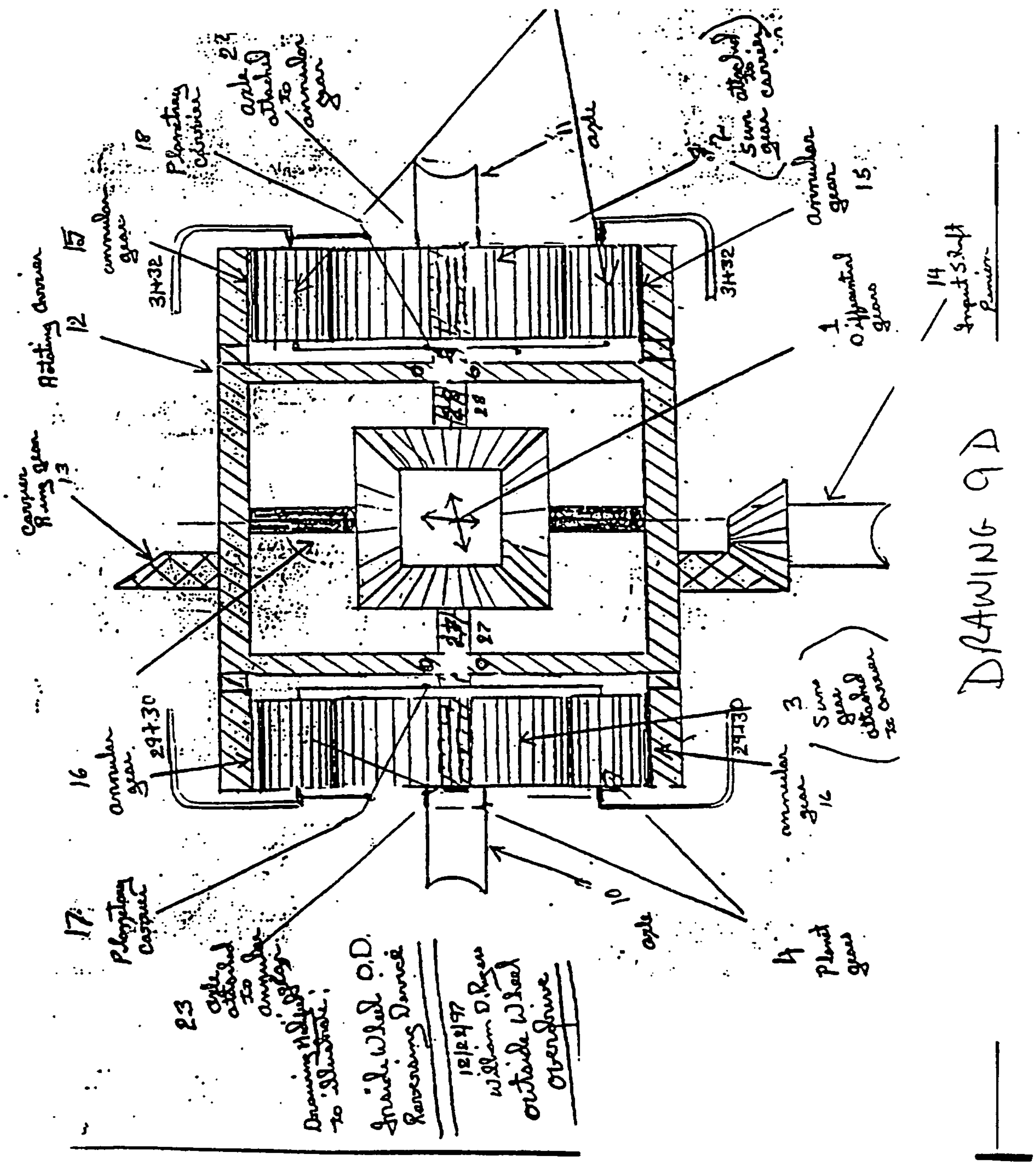

DRAWING 9c
Rotating Carrier 12
annular gear 15
annular gear 16
Planetary Carrier 18
Planetary Carrier 17
axle 11
axle 10
Planet gears 4
Differential gears 1
Input Shaft Pinion 14
Carrier Ring gear 13
Sun gear attached to carrier 3
SHAFT
Inside Wheel Reversing Device
With Brake Control 1/7/98
12/24/97 William D. Rees
Outside Wheel Overdrive

Fig 1

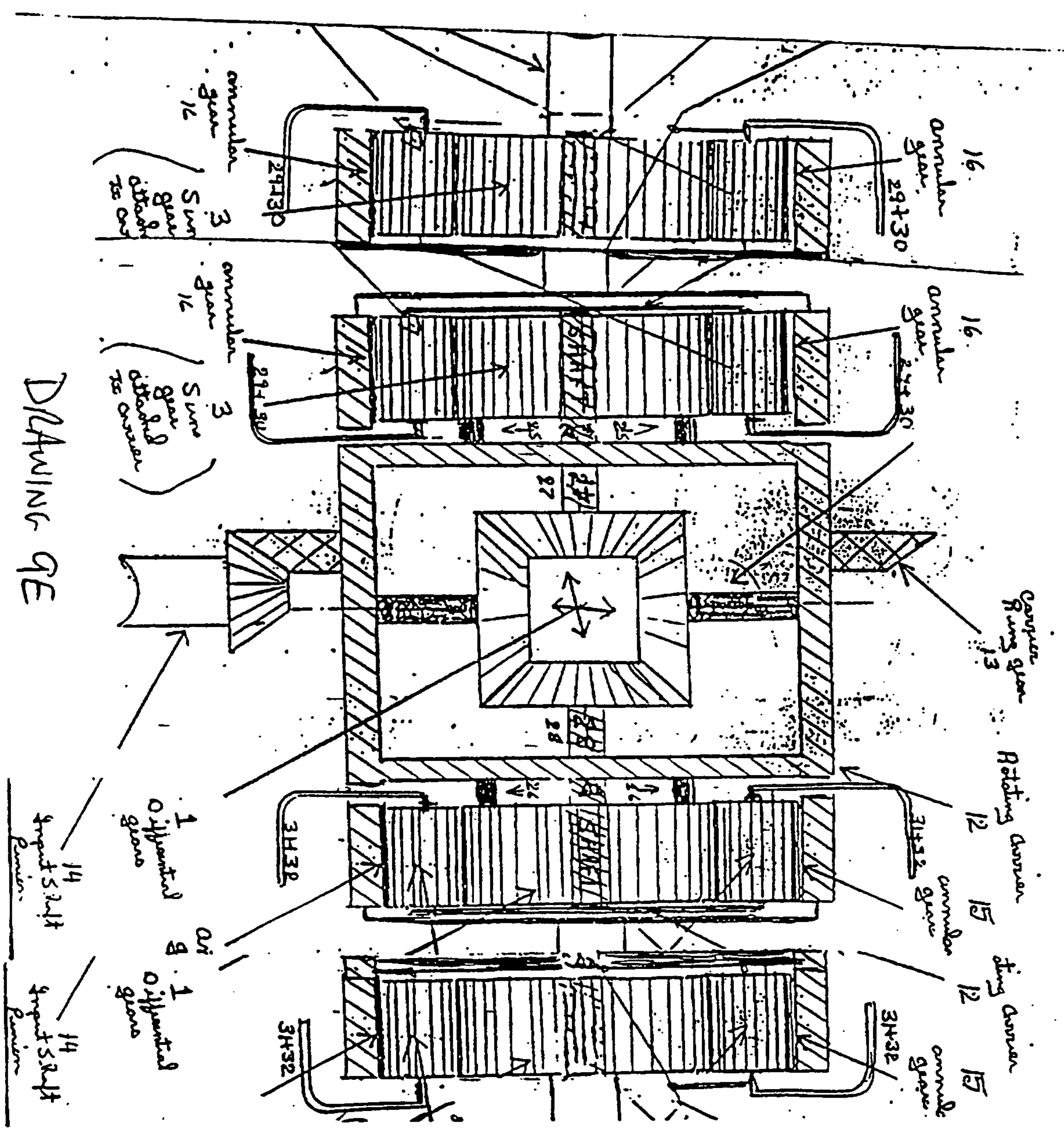
Fig 2

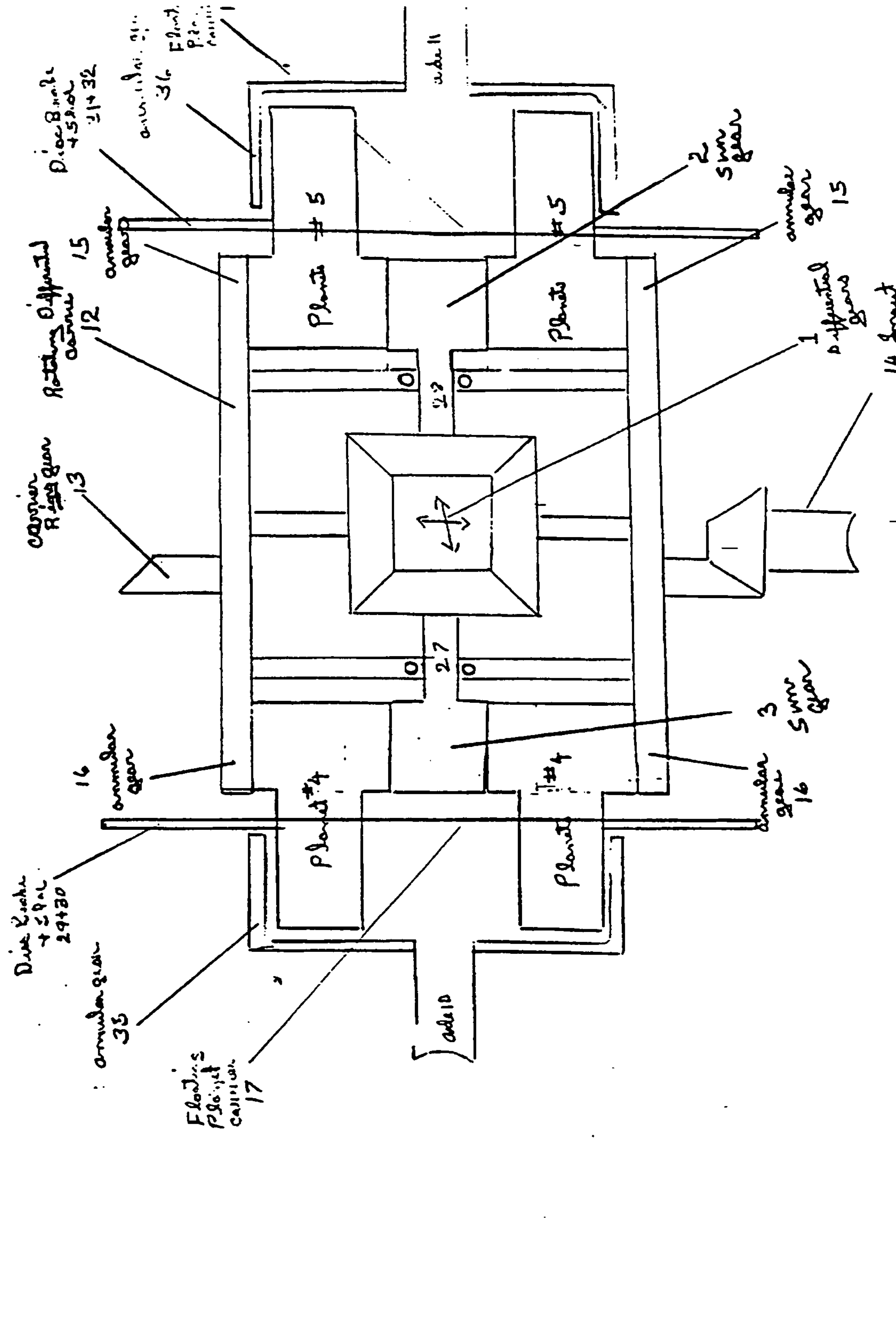


DRAWING 13

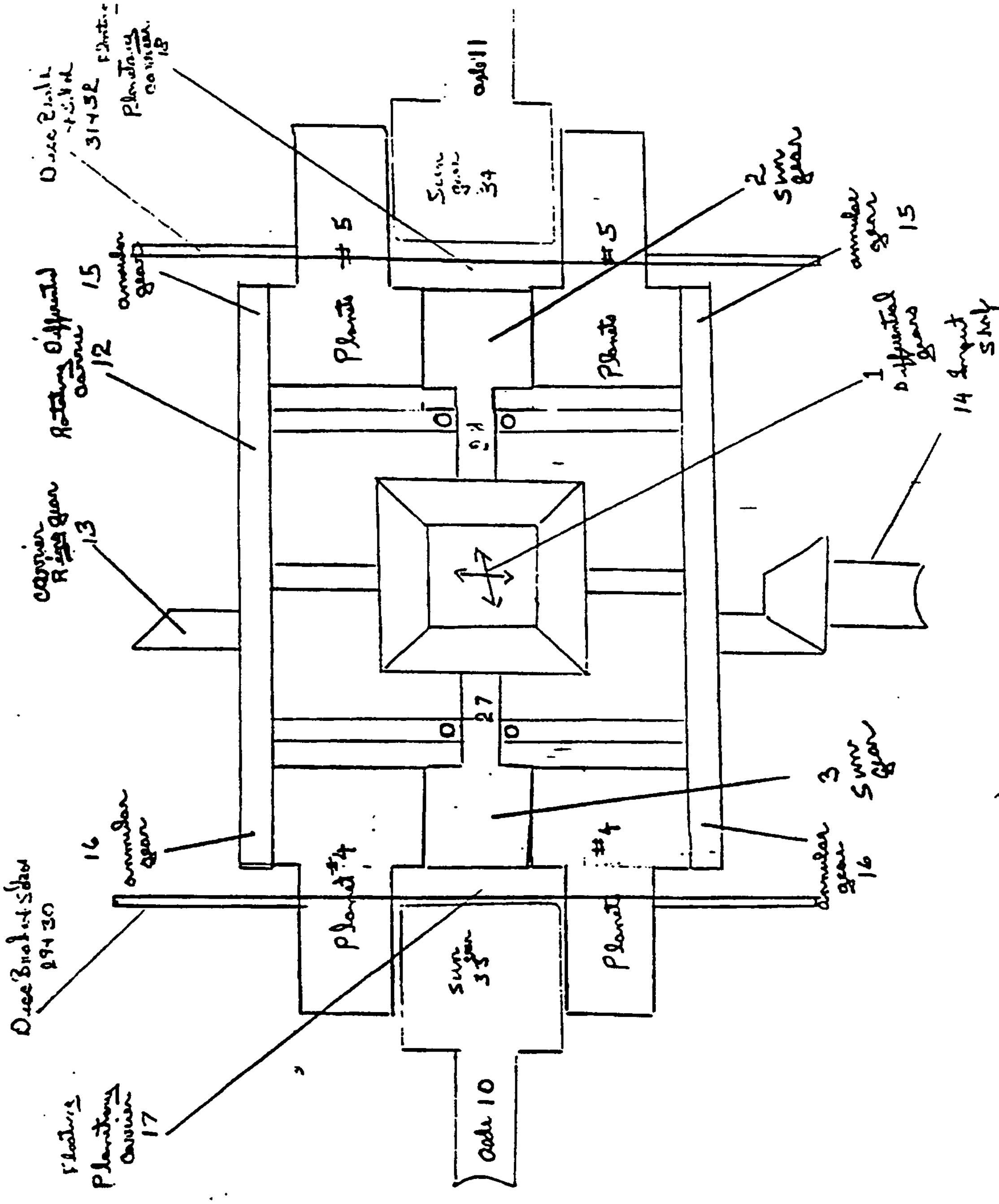

Rotating carrier
12
annular gear
15
Planetary carrier
18
axle
11
annular gear
15
Differential gears
1
14
Input Shaft Pinion
Carrier Ring gear
13
annular gear
16
Sun gear attached to carrier
3
annular gear
16
Planet gears
4
axle
10
17
Planetary carrier
23
Inside Wheel O.D. Reversing Device
12/24/97
William D. Rees
Outside Wheel Overdrive

DRAWING 9D

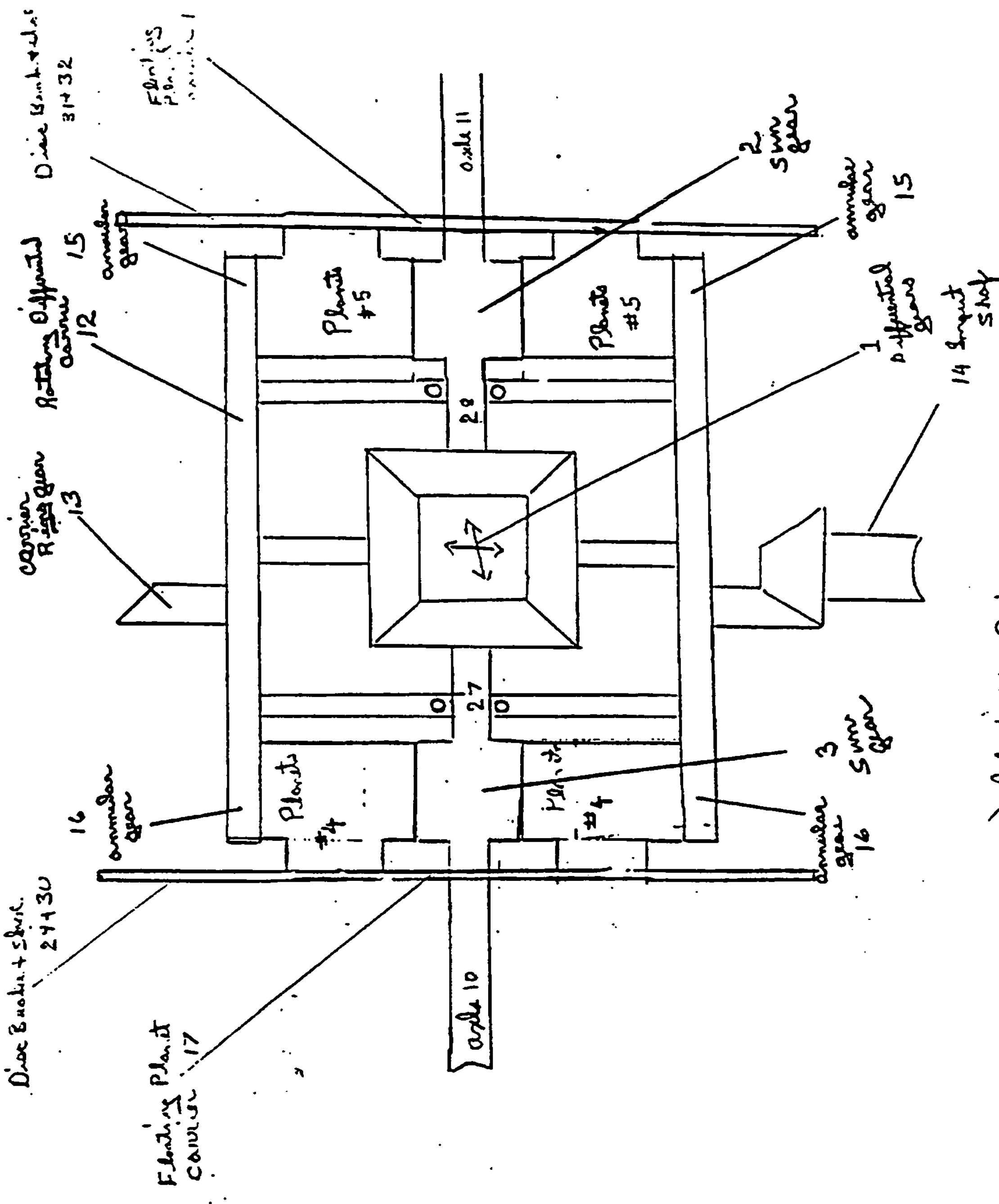

DRAWING 9E
annular gear 16
29+30
Sun gear attached to carrier 3
SHAFT
27
28
Carrier Ring gear 13
Rotating carrier 12
annular gear 15
31+32
Differential gears 1
Input Shaft Pinion 14
Air gap 9


Planets #5
Planets #4
sun gear
2
sun gear
3
annular gear
15
annular gear
16
Rotating Differential carrier
12
13
differential gears
1
14 Input shaft
27
annular gear
35
17

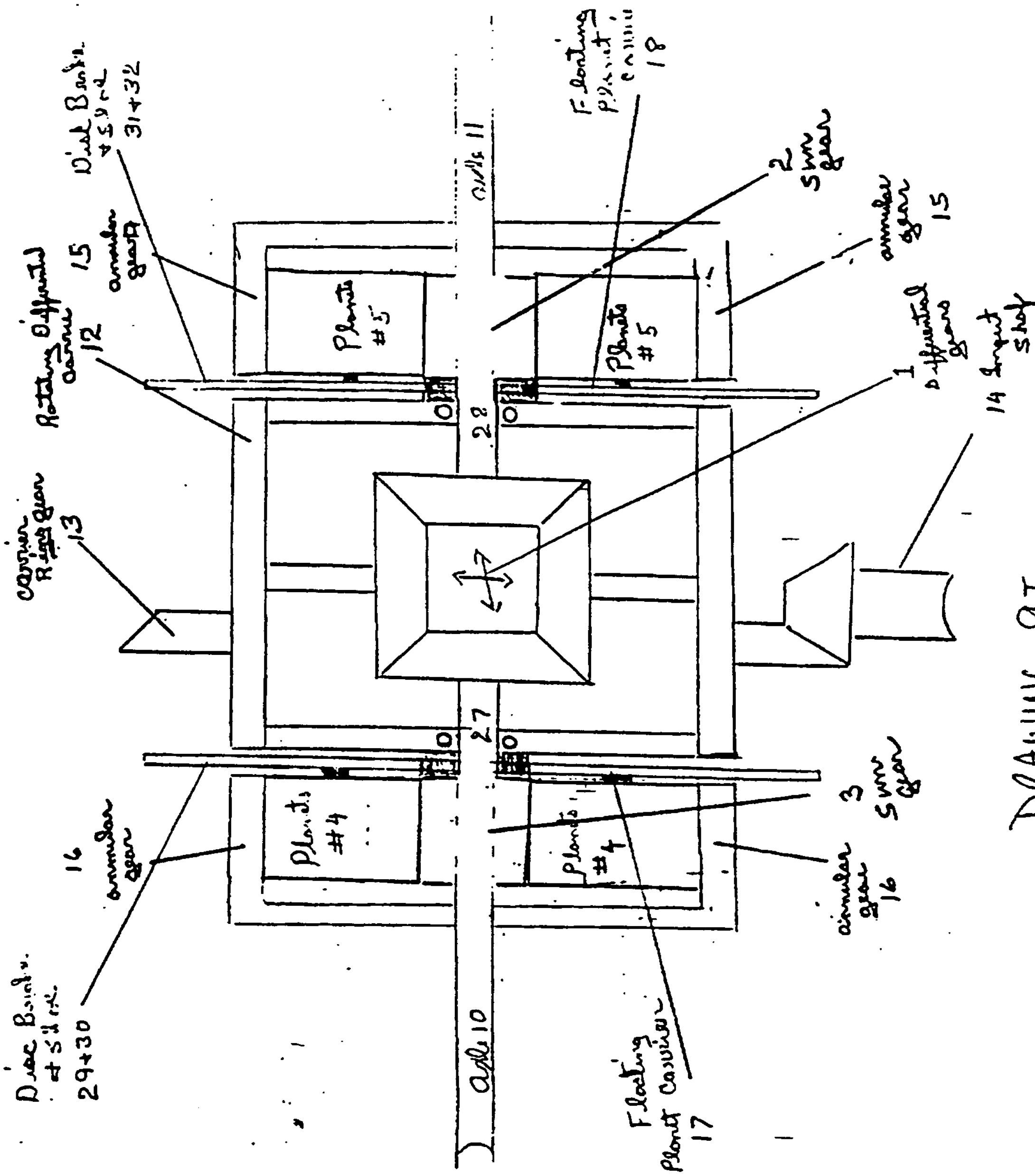
DRAWING 9F



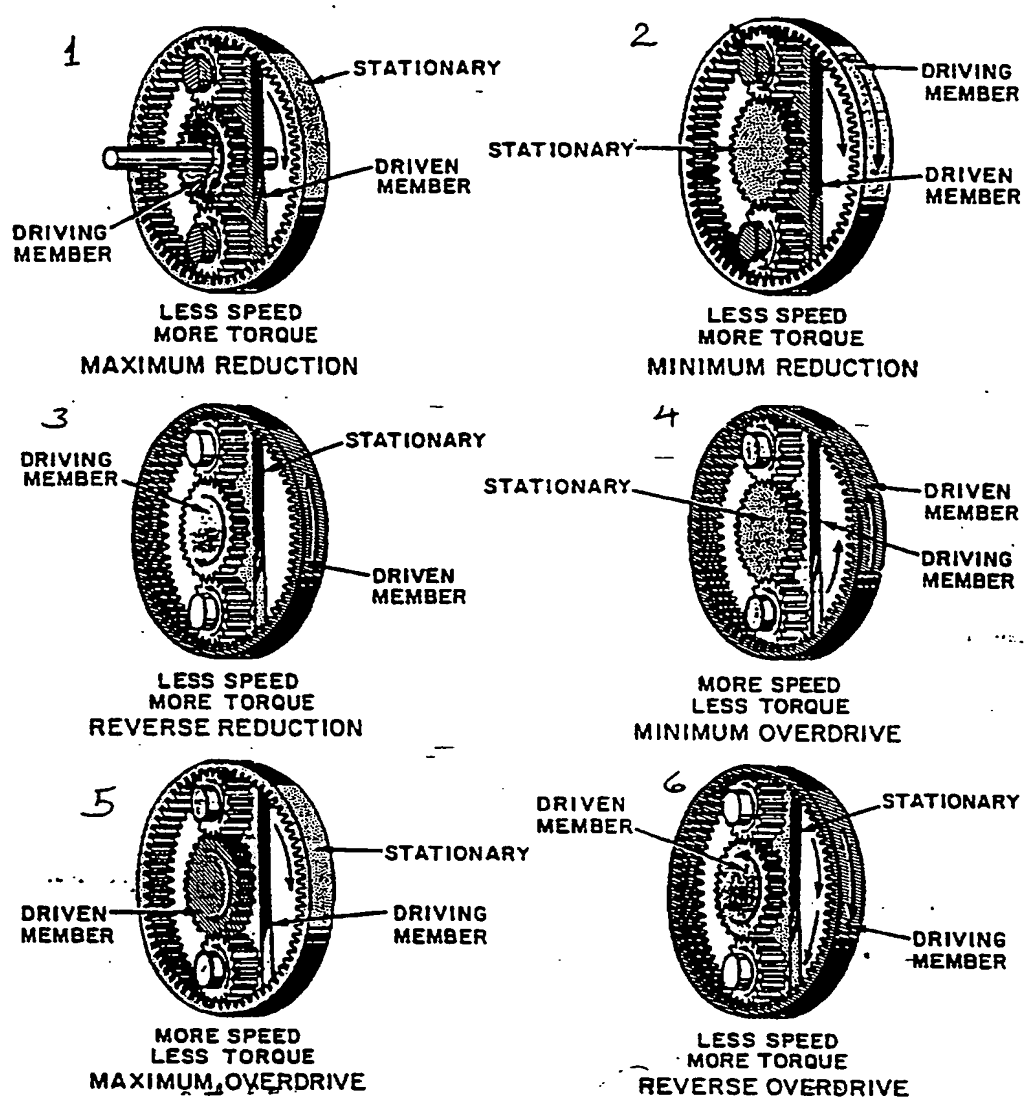
DRAWING 9G


axle 11
2 sun gear
annular gear 15
15 annular gear
Rotating Differential arms 12
Planets #5
Planets #5
1 Differential gears
14 Input Shaft
28
carrier Ring gear 13
27
3 sun gear
Planets #4
Planets #4
16 annular gear
annular gear 16
Disc Brake + shoe 29+30
axle 10
Floating Planet carrier 17

DRAWING 9H


Disk Brake + Spline 31+32
Floating Planet carrier 18
2 sun gear
15 annular gear
annular gear 15
Rotating Differential carrier 12
1 differential gears
14 input shaft
carrier Ring gear 13
Planets #5
Planets #5
22
27
Planets #4
Planets #4
3 sun gear
16 annular gear
annular gear 16
Disc Brake + Spline 29+30
Floating Planet Carrier 17
axle 10
axle 11

DRAWING 9I


1
STATIONARY
DRIVEN MEMBER
DRIVING MEMBER
LESS SPEED
MORE TORQUE
MAXIMUM REDUCTION
2
DRIVING MEMBER
STATIONARY
DRIVEN MEMBER
LESS SPEED
MORE TORQUE
MINIMUM REDUCTION
3
STATIONARY
DRIVING MEMBER
DRIVEN MEMBER
LESS SPEED
MORE TORQUE
REVERSE REDUCTION
4
STATIONARY
DRIVEN MEMBER
DRIVING MEMBER
MORE SPEED
LESS TORQUE
MINIMUM OVERDRIVE
5
STATIONARY
DRIVEN MEMBER
DRIVING MEMBER
MORE SPEED
LESS TORQUE
MAXIMUM OVERDRIVE
6
DRIVEN MEMBER
STATIONARY
DRIVING MEMBER
LESS SPEED
MORE TORQUE
REVERSE OVERDRIVE

DRAWING 10 -

Planetary Gear Sets

Other types of power shift transmissions use a combination of PLANETARY GEAR SETS to perform the same functions as the transmission just described.

A planetary gear set (fig. 11-28) consists of three members: sun gear, ring gear, and planetary carrier which holds the planetary gears in proper relation with the sun and ring gear. The planetary gears are free to rotate on their own axes while they "walk" around the sun gear or inside the ring gear.

To cause a reduction or increase in torque, six different methods of connecting this gear set to the power train are possible. Another method provides direct drive and neutral can be obtained by allowing all the gears to turn freely. By comparing the chart shown in figure 11-29 to the simple planetary gear arrangements shown in figure 11-30, you can see how this is possible.

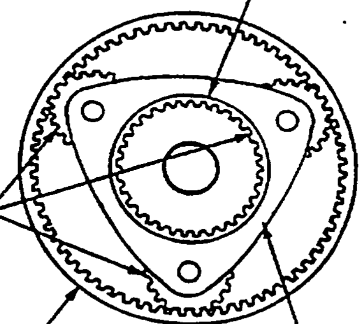


Figure 11-28.—Planetary gear set.

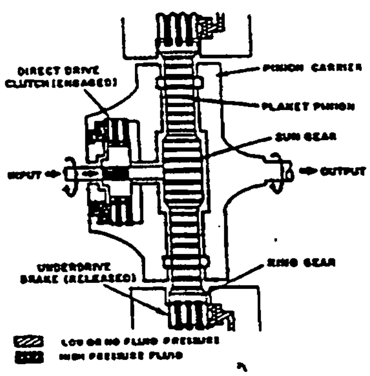
CASE	STATIONARY MEMBER	DRIVING MEMBER	DRIVEN MEMBER	RESULT
ONE	RING	SUN	CARRIER	MAXIMUM REDUCTION
TWO	SUN	RING	CARRIER	MINIMUM REDUCTION
THREE	CARRIER	SUN	RING	REVERSE REDUCTION
FOUR	SUN	CARRIER	RING	MINIMUM OVERDRIVE
FIVE	RING	CARRIER	SUN	MAXIMUM OVERDRIVE
SIX	CARRIER	RING	SUN	REVERSE OVERDRIVE
SEVEN	NONE (TWO LOCKED TOGETHER)	ANY	ANY	DIRECT DRIVE
EIGHT	NONE	ANY	NONE	NEUTRAL

DRAWING 11A

Notice the direction of rotation as power is applied to the various members and others are held stationary. In actual application, planetary gear sets are used as single or multiple units, depending on the number of speed (gear) ranges desired.

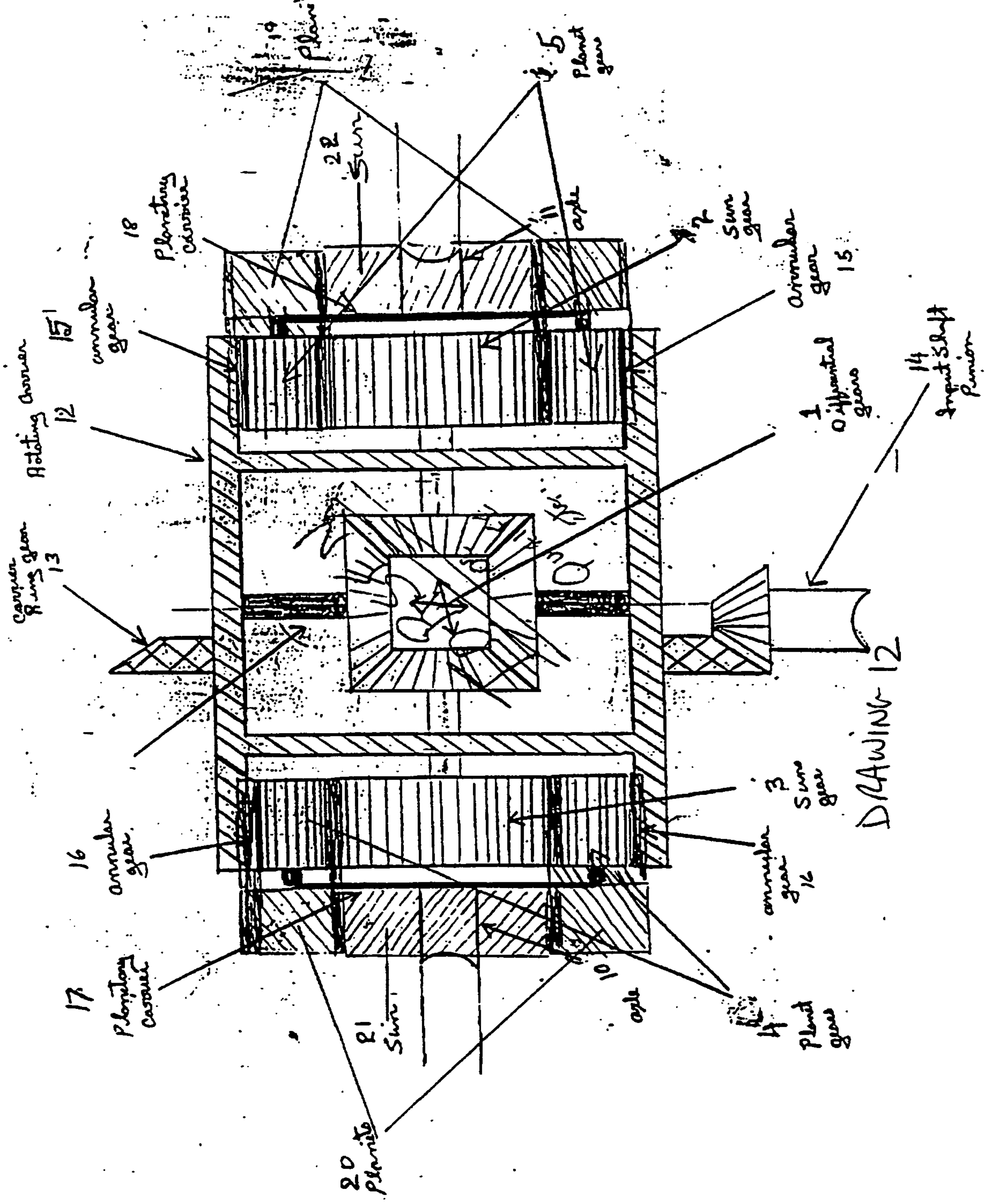
On wheel or crawler mounted equipment, power for turning the wheels or drive sprockets may flow through a planetary gear arrangement that provides maximum reduction. (See fig. 11-30.) The sun gear forces the planet gears to revolve inside the stationary ring gear and move the planet carrier in the same direction of rotation as the sun gear. The planet carrier is connected to the hub on which the wheel or sprocket is mounted, causing it to rotate with the planet carrier. This arrangement produces the maximum torque and speed reduction obtainable from a planetary gear set.

Figure 11-31 illustrates the simplest application of planetary gears in a transmission. With the arrangement shown, two forward speeds and neutral are possible. High gear or direct drive is shown. The clutch is holding the planet carrier to the input shaft causing the carrier and sun gear to rotate as a single unit. With the clutch released, all gears are free to rotate and no power is transmitted to the output shaft. In neutral, the planetary carrier remains stationary while the pinion gears rotate on their axes and turn the ring gear. Should the brake be engaged on the ring gear, the sun gear causes the planetary gears to walk around the inside of the ring gear and force the planet carrier to rotate in the same direction as the sun gear, but at a slower speed (low gear). To provide additional speed ranges or a reverse, other planetary gear sets must be added to this transmission. A power shift transmission with planetary gears can be made to operate automatically by changing the method of controlling speed changes.

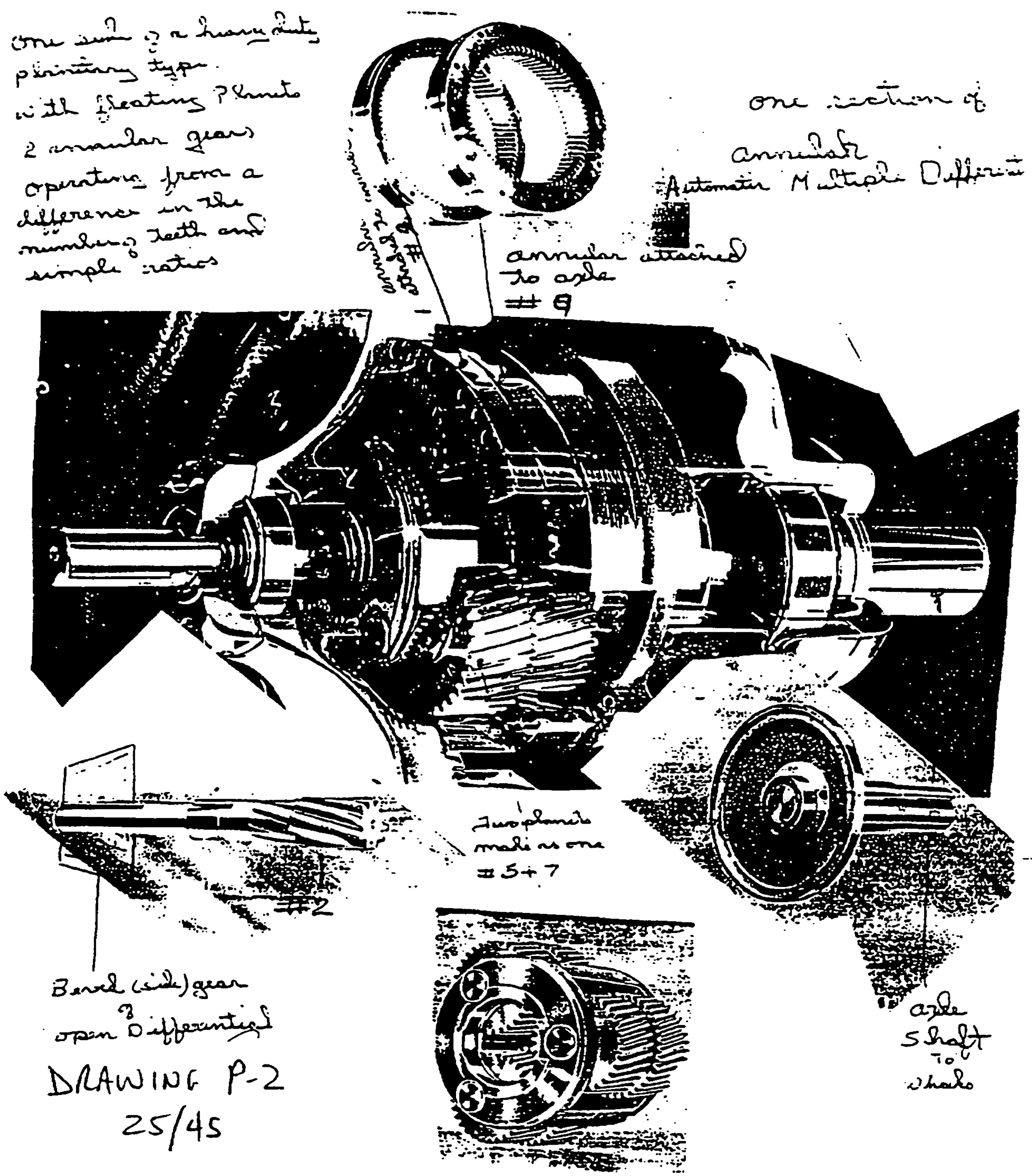


—Simple planetary gear application.

DRAWING 11B


Rotating carrier 12
Carrier Ring gear 13
annular gear 15'
Planetary carrier 18
Sun 22
Planet gear 5
axle 11
Sun gear 2
Annular gear 15
Differential gears 1
Input Shaft Pinion 14
Sun gear 3
annular gear 16
annular gear 16
Planetary carrier 17
Sun 21
axle 10
Planet gears 4
Planets 20
DRAWING 12

one unit of a heavy duty planetary type with floating planets 2 annular gears operating from a difference in the number of teeth and simple ratios



DRAWING P-2
25/45

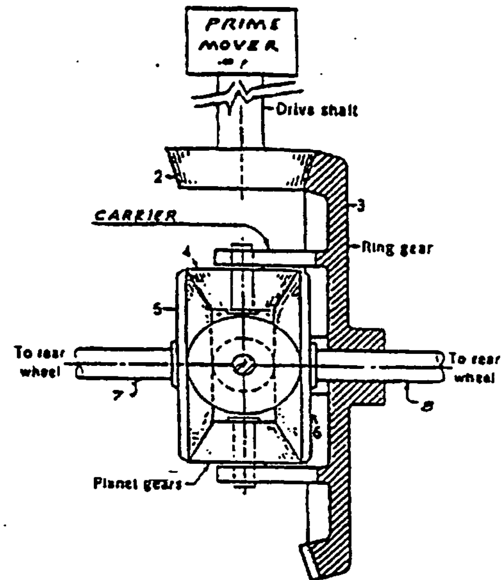


FIG. 1 TYPICAL BEVEL-GEAR DIFFERENTIAL Open

William D. Rogers Co-Inventor
9/2/97

DRAWING Eng-1

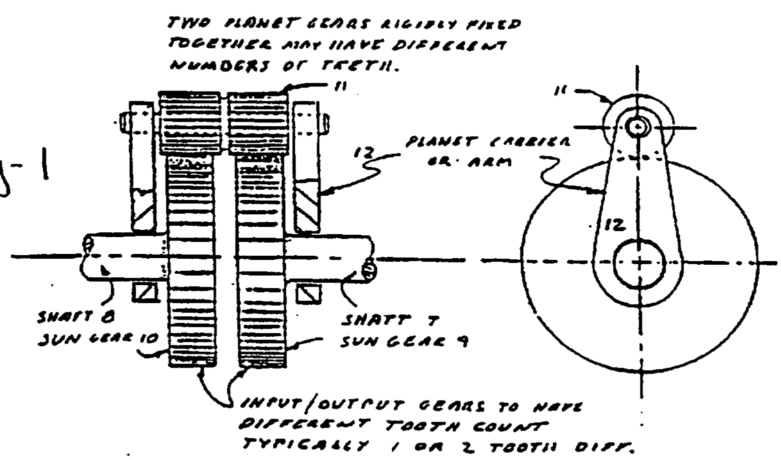


FIG. 2 TYPICAL PLANETARY GEAR TRAIN

Multiple Differential

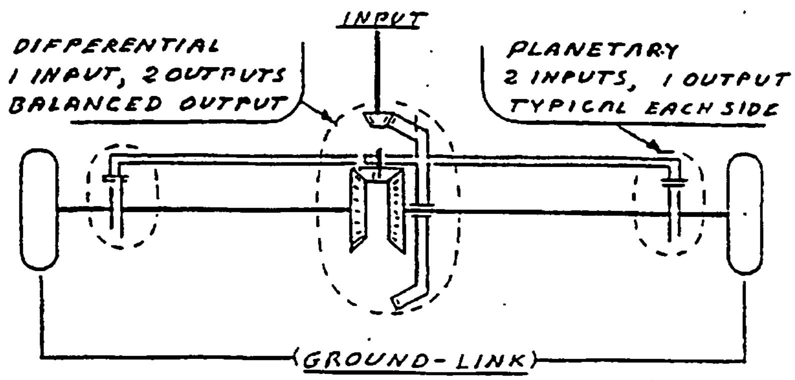
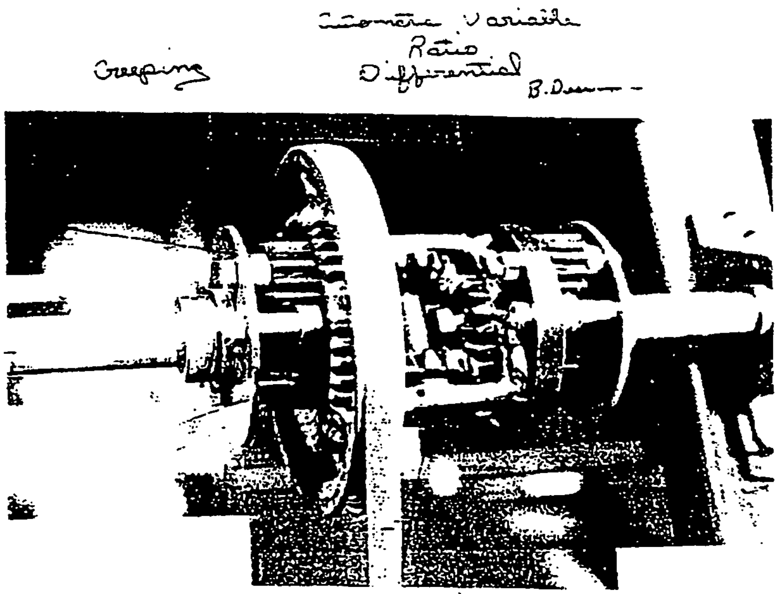
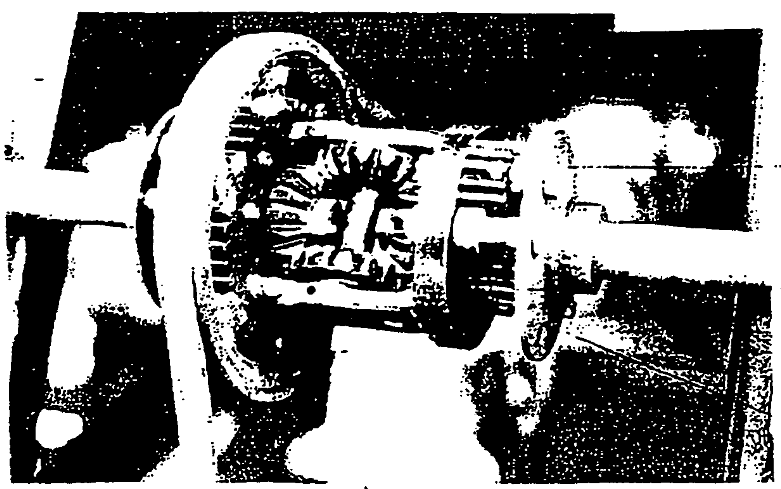


FIG. 3 TYPICAL ASSEMBLY SCHEMATIC

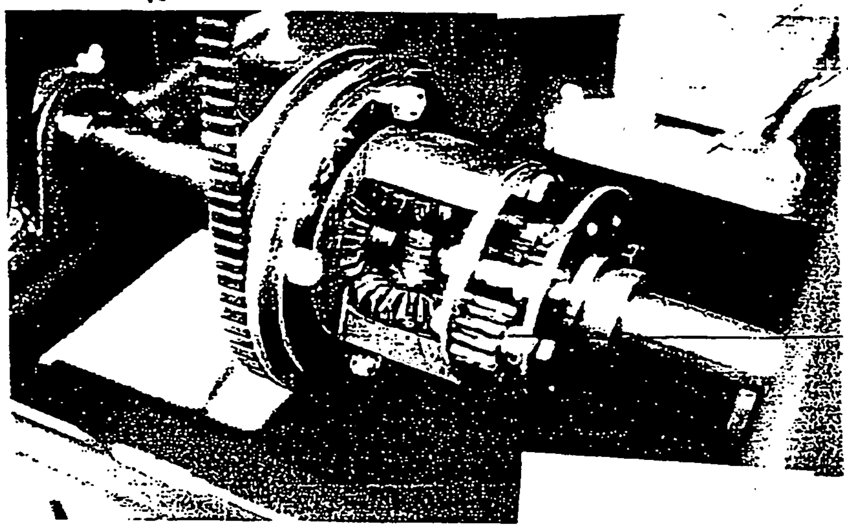
DRAWING Eng2



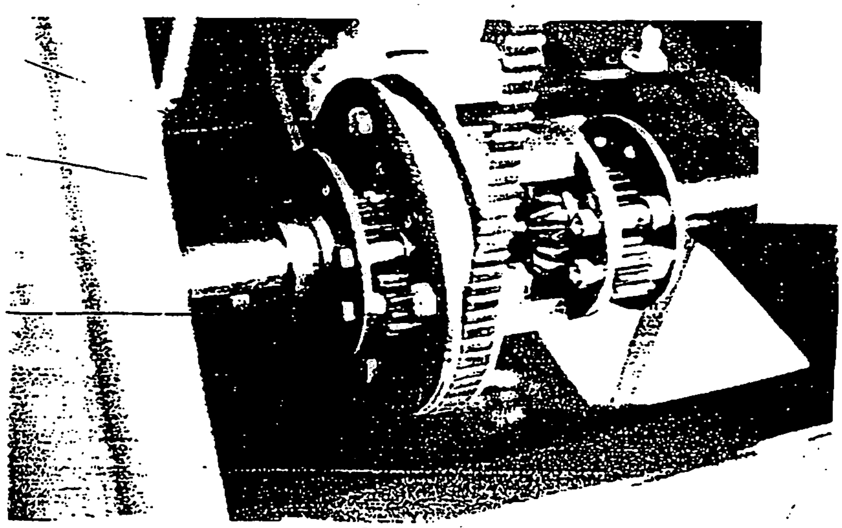
DRAWING P3-A



DRAWING P-3B

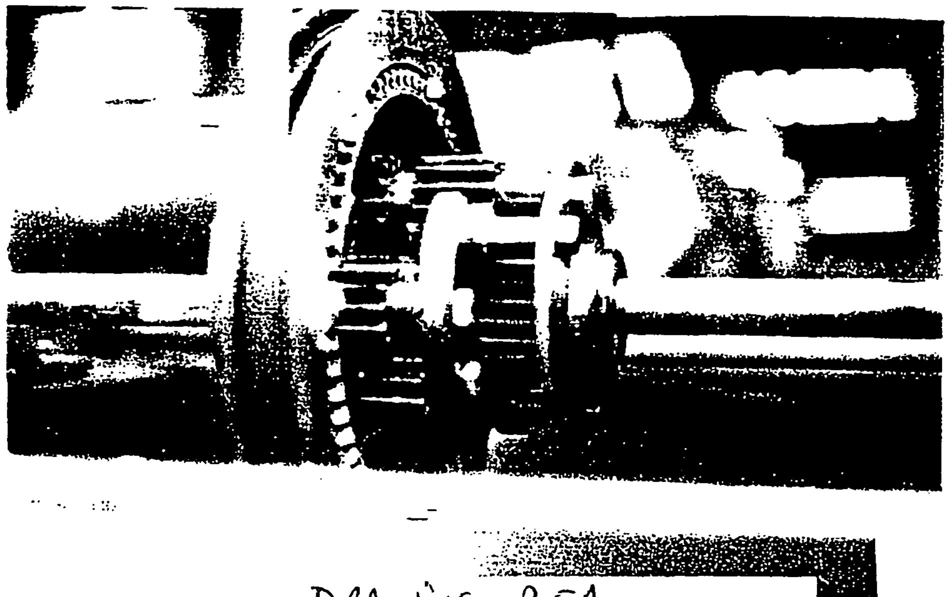


DRAWING P-4A

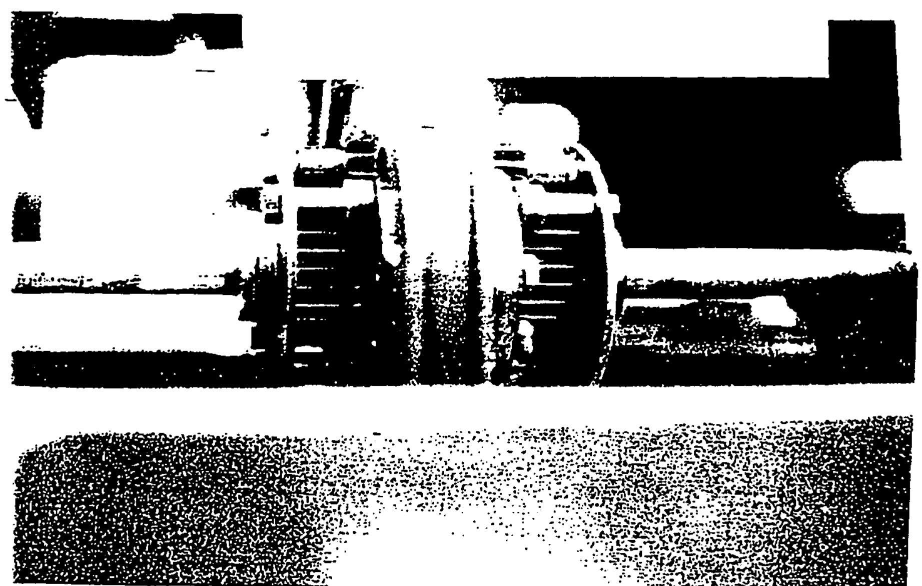


DRAWING P-4B

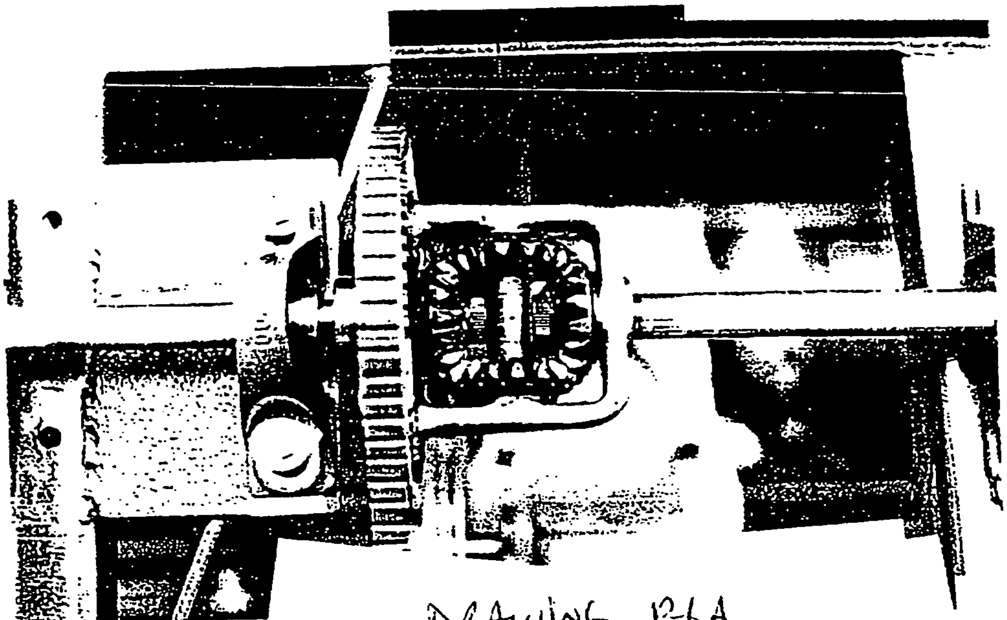
Automatic Variable Ratio
Differential
(using spur gear cam differential)



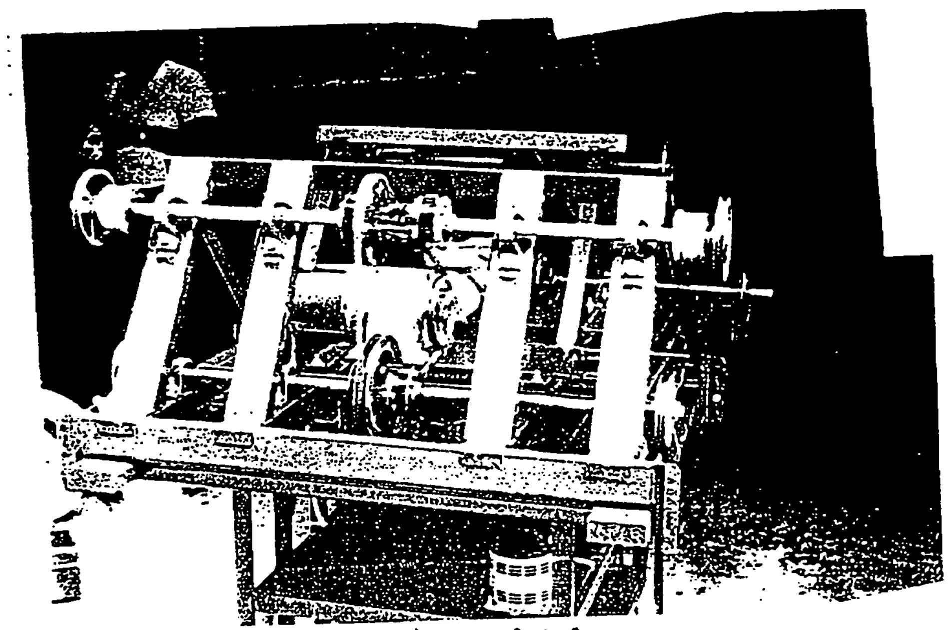
DRAWING P-5A



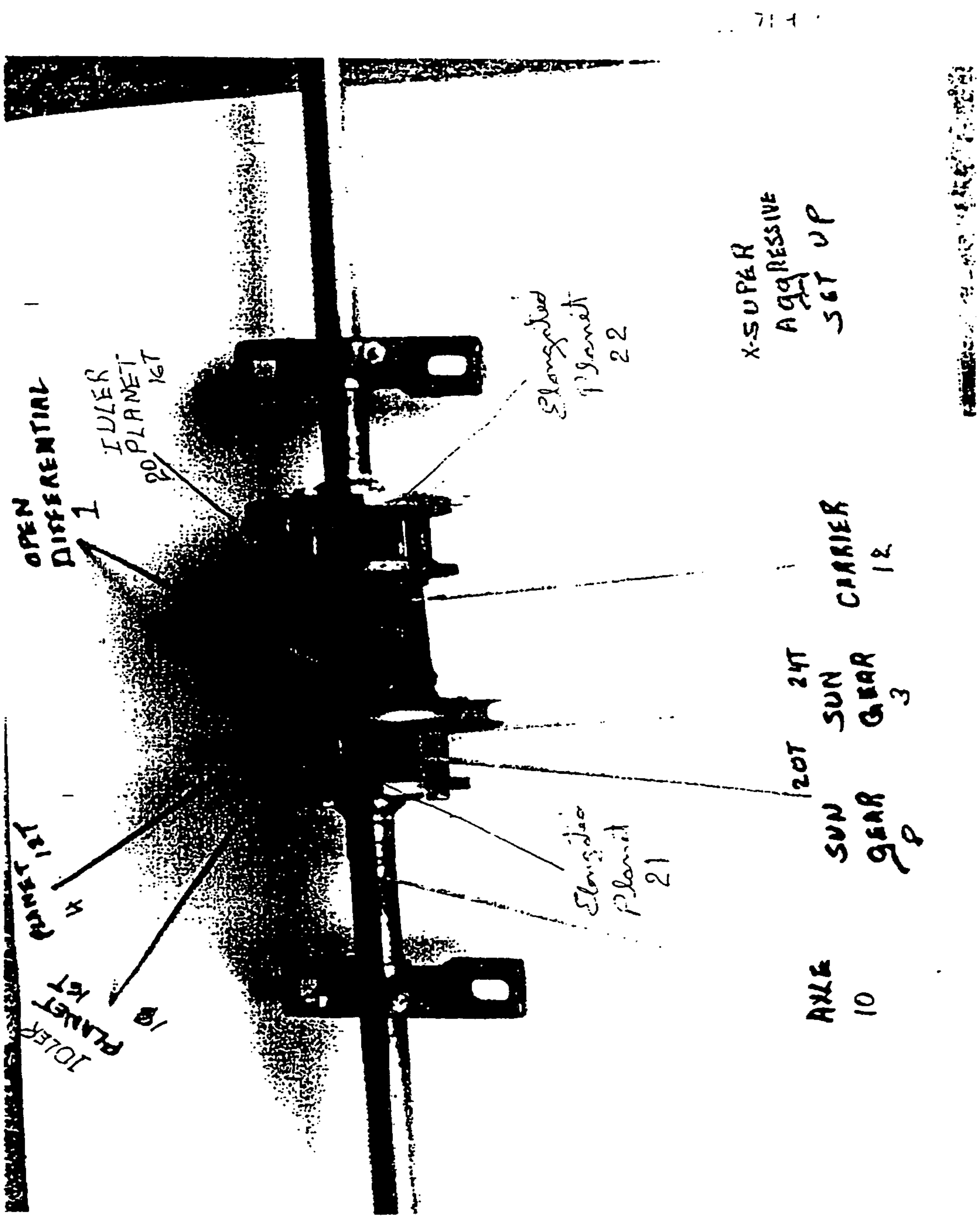
DRAWING P-5B



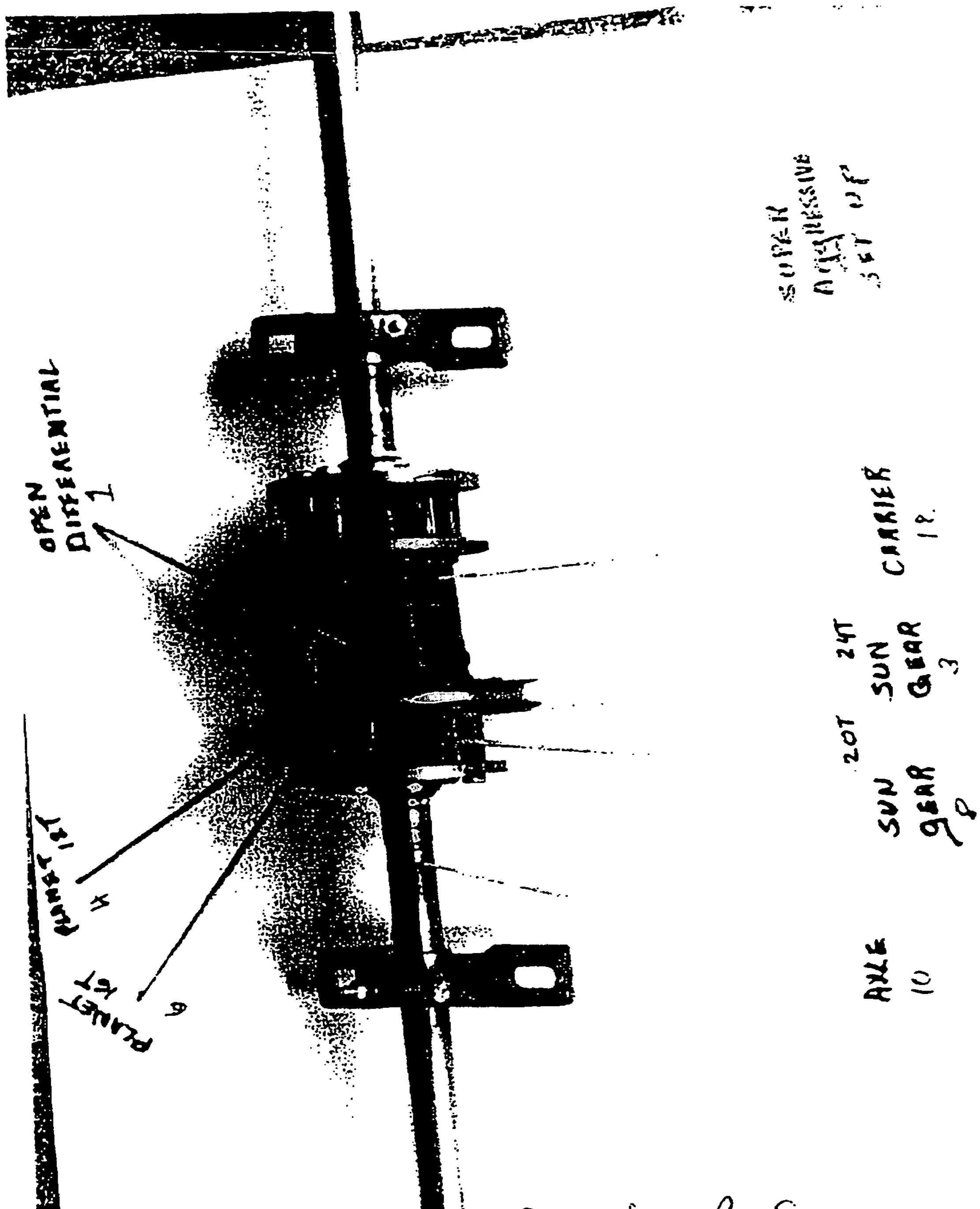
DRAWING P-6A



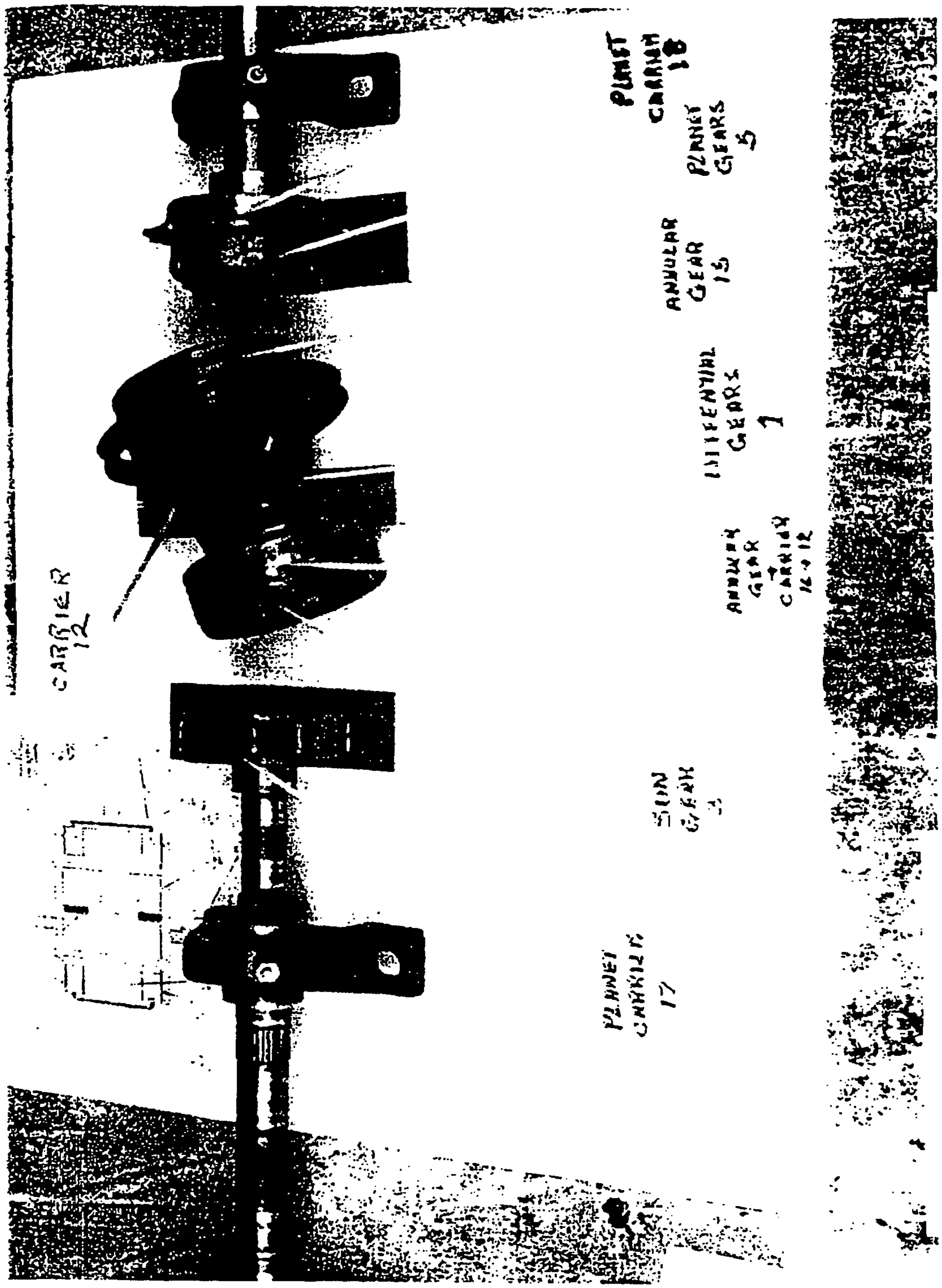
DRAWING P-6B


OPEN DIFFERENTIAL 1
IDLER PLANET 16T 20
Elongated Planet 22
X-SUPER Aggressive SET UP
CARRIER 12
24T SUN GEAR 3
20T SUN GEAR 2
Elongated Planet 21
AXLE 10
PLANET 12T 4
IDLER PLANET 16T 19

DRAWING P-7

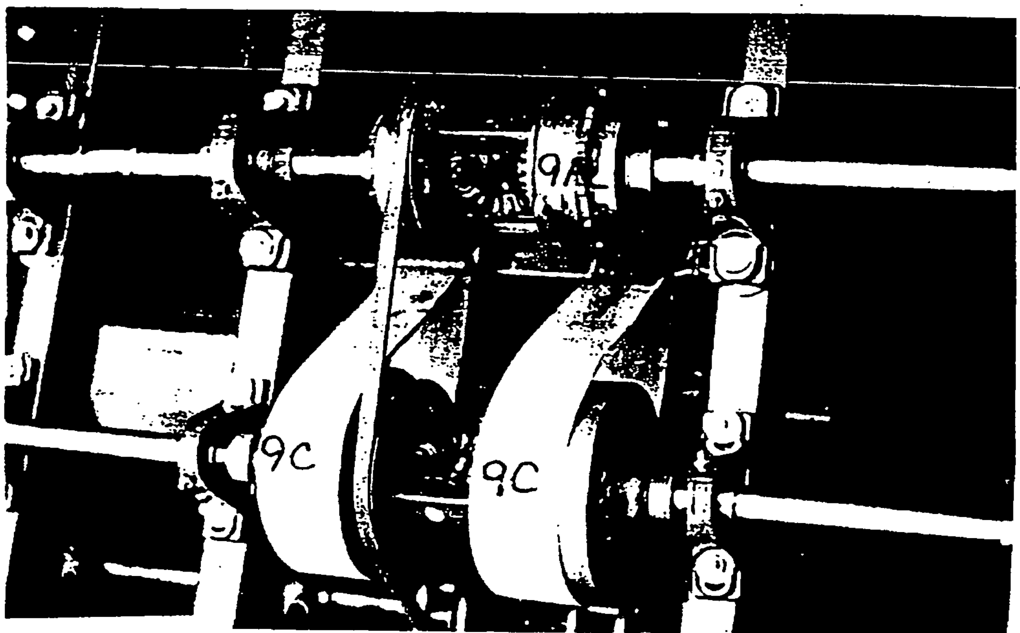

OPEN DIFFERENTIAL 1
PLANET 1st 4
PLANET KIT 6
CARRIER 12
24T SUN GEAR 3
20T SUN GEAR
AXLE 10

DRAWING P-8

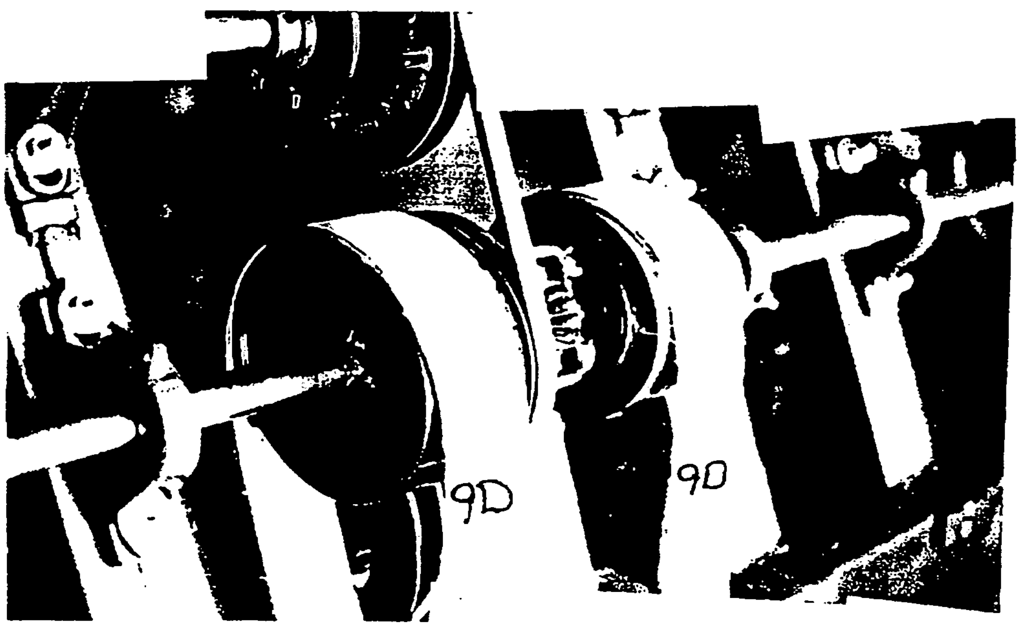

PLANET CARRIER 18
PLANET GEARS 5
ANNULAR GEAR 15
GEARS 1
CARRIER 12
SUN GEAR 3
PLANET CARRIER 17

DRAWING P-9A

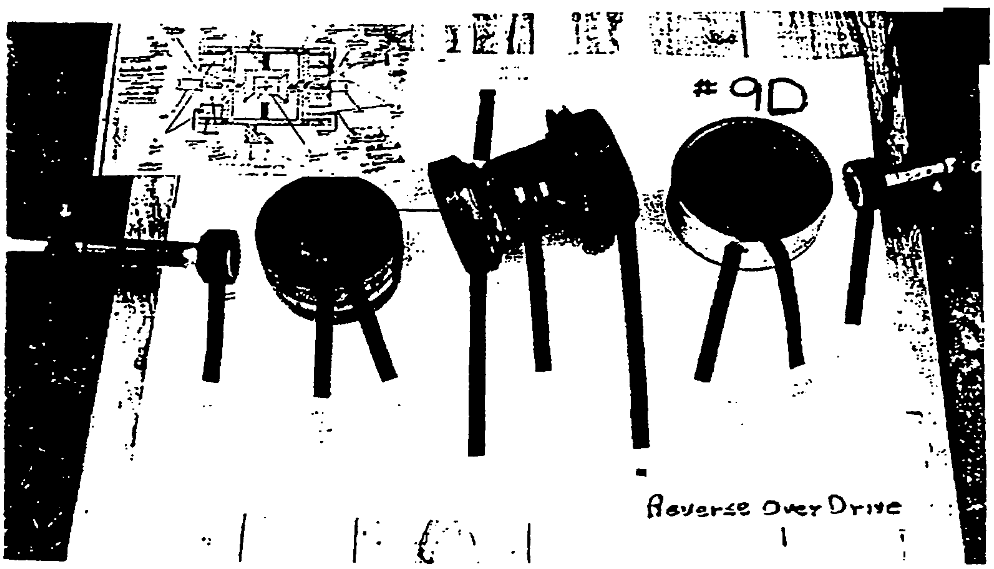
Automatic Variable Ratio Differential AVRD



DRAWING P-9B



DRAWING P-9C



DRAWING P-9D

DRAWING P-9E

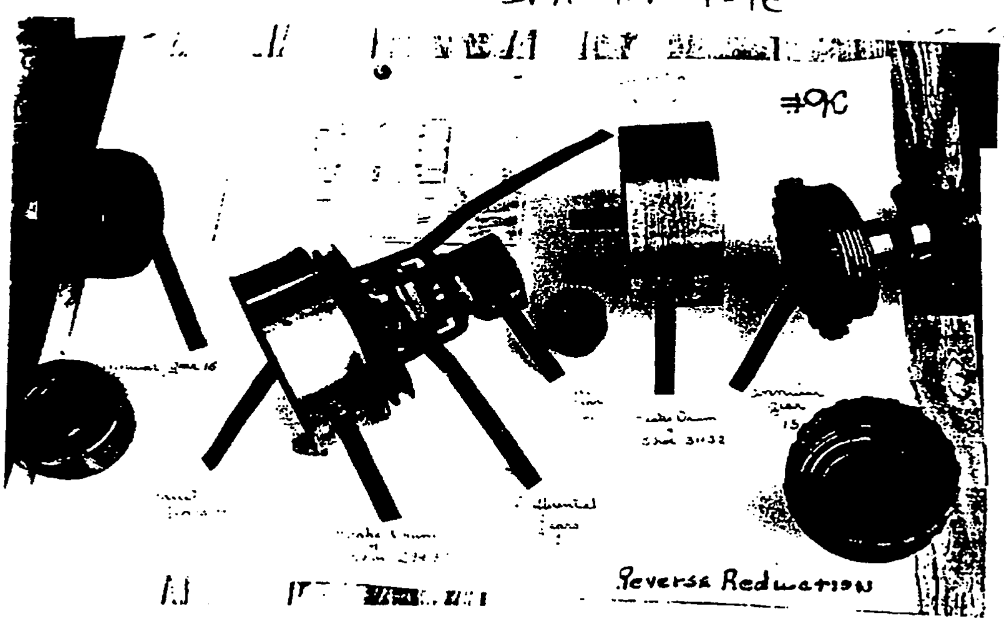


Fig 1

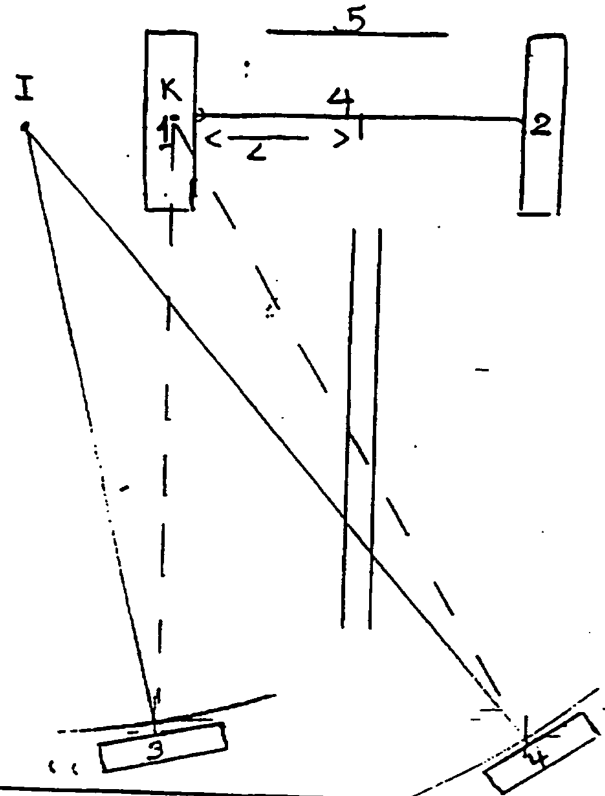


Fig 2

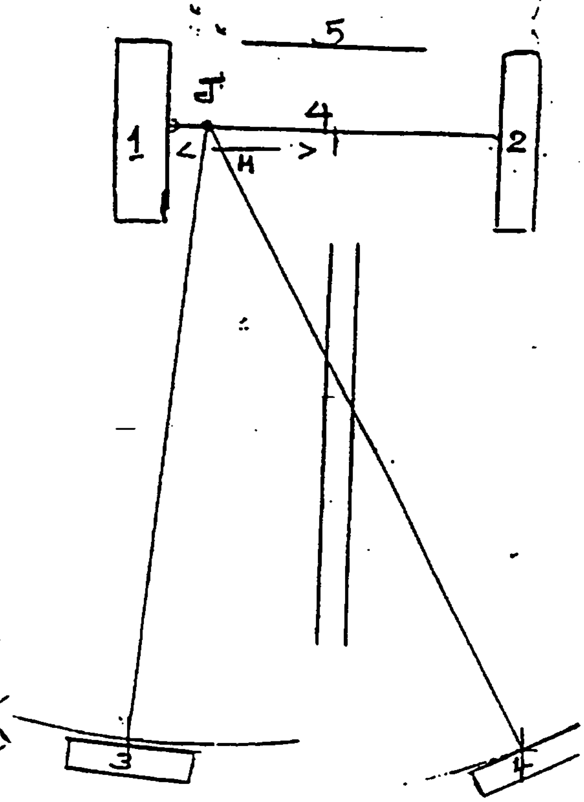
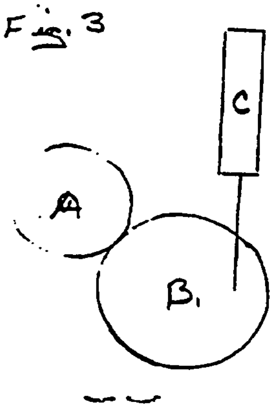
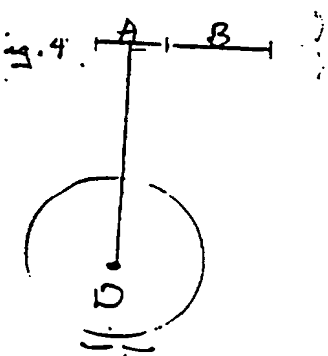


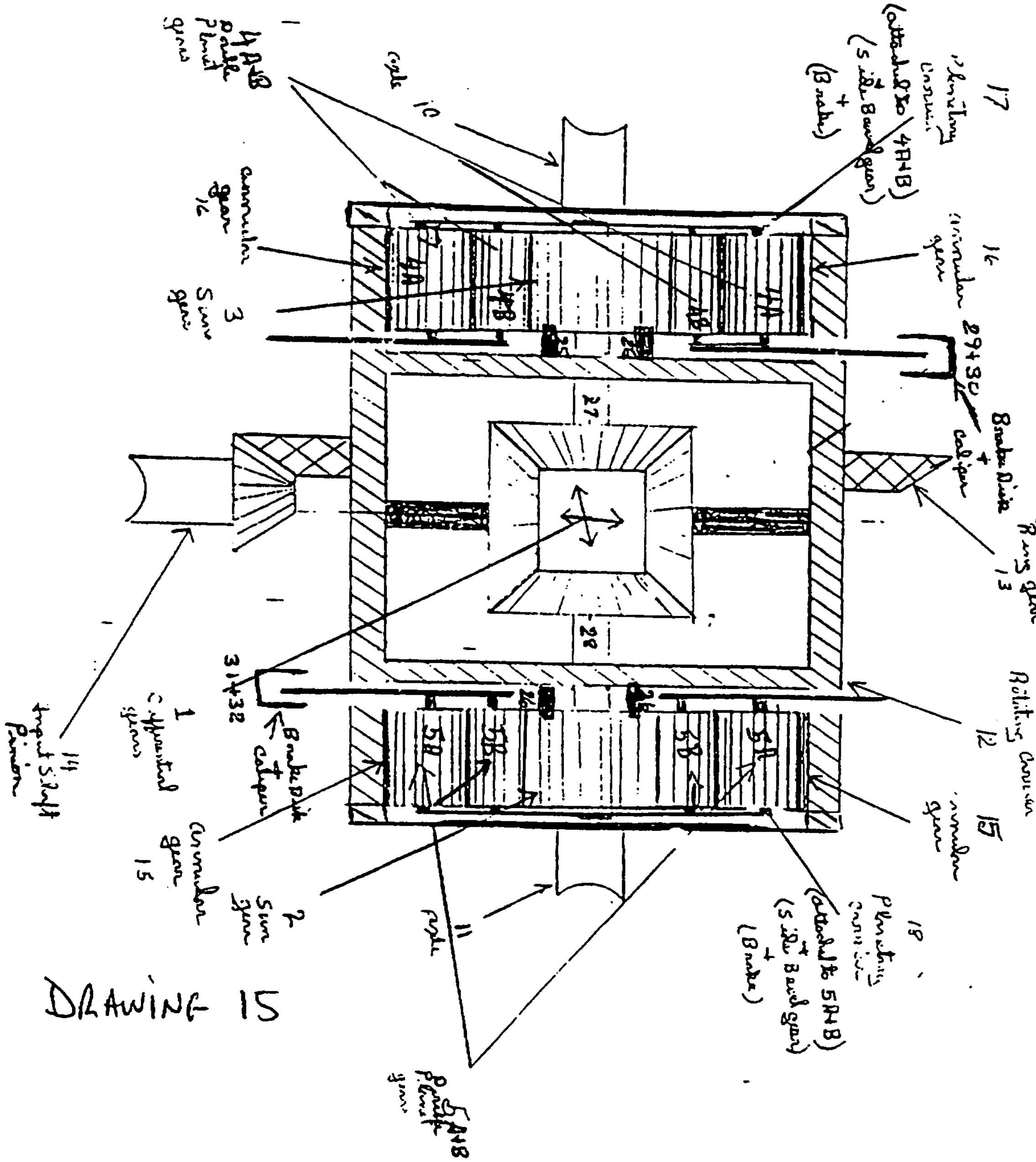
Fig. 3



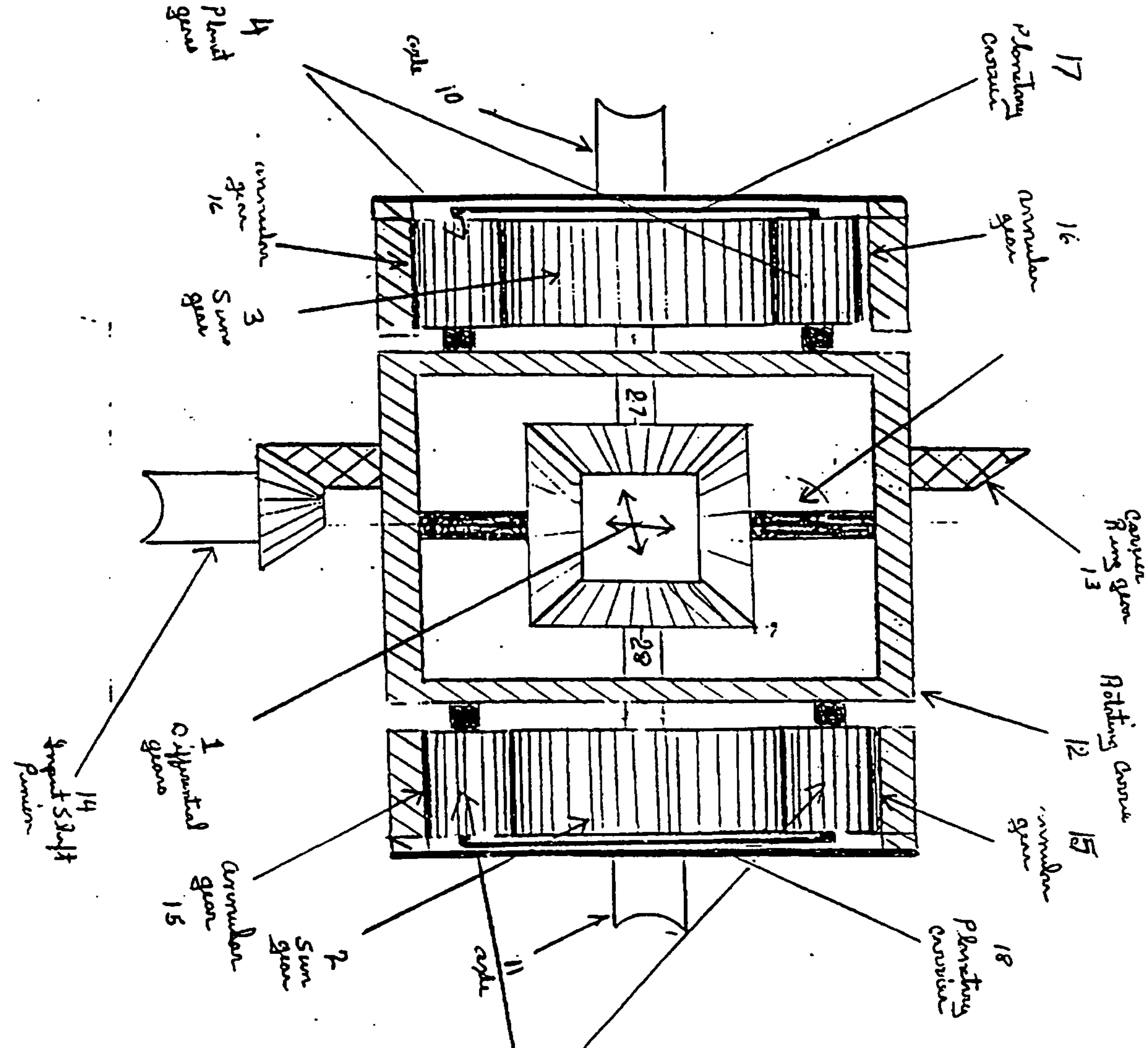
DRAWING 14

ig. 4

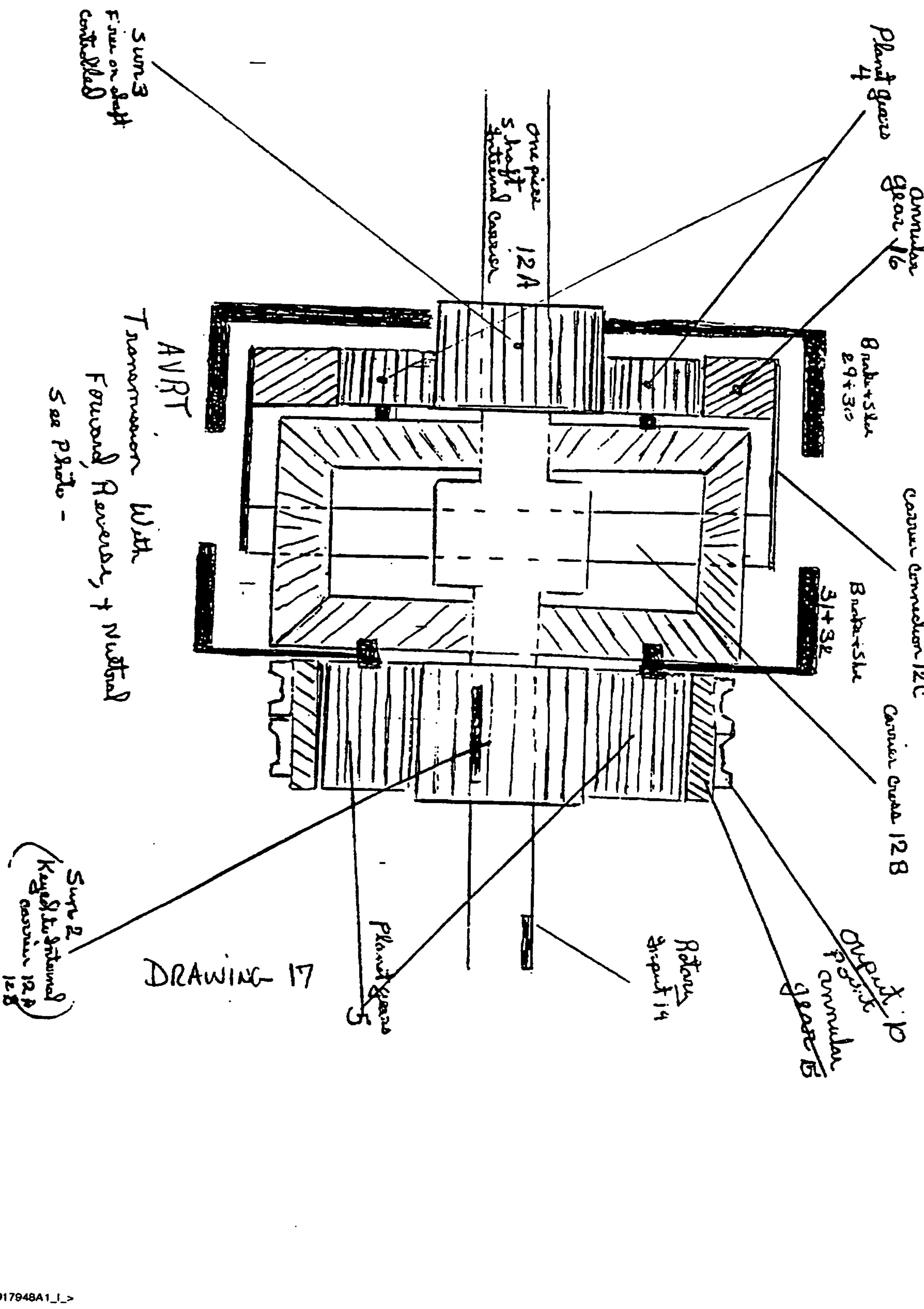




DRAWING 15


4 Planet gears
axle 10
17 Planetary carrier
annular gear 16
16 annular gear
3 Sun gear
27
28
Carrier Ring gear 13
1 Differential gears
Rotating carrier 12
14 Input Shaft Pinion
15 annular gear
Annular gear 15
2 Sun gear
axle 11
18 Planetary carrier
5 Planet gear

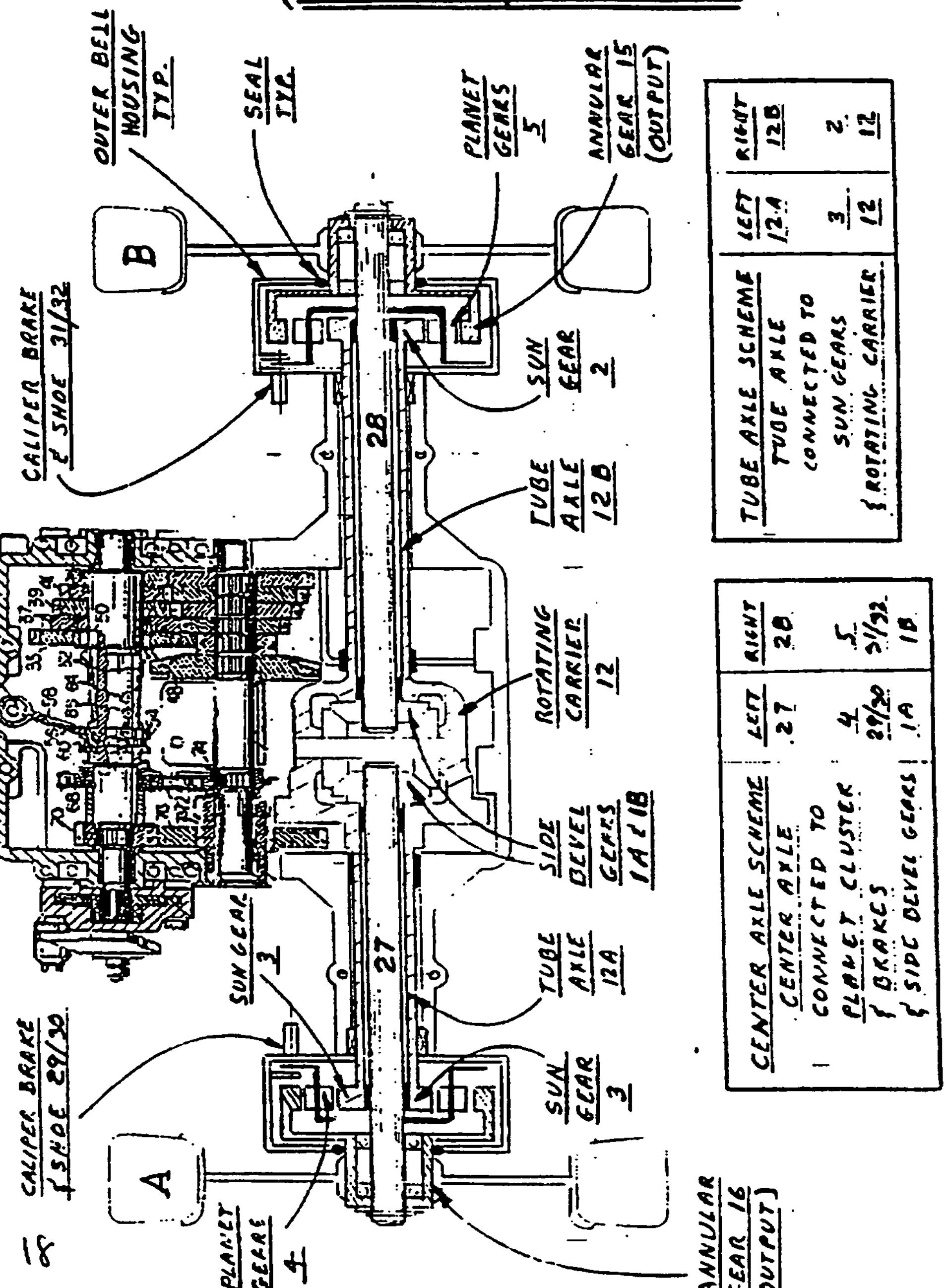
DRAWING 16


Sun 3
Free on shaft
controlled
One piece
shaft
internal carrier 12A
Planet gears
4
Annular
gear 16
Brake + Shoe
29 + 30
Carrier connection 12C
Brake + Shoe
31 + 32
Carrier cross 12B
Output 10
Point
annular
gear 15
Rotary
input 14
Planet gears
5
Sun 2
(Keyed to internal
carrier 12A
12B)
AVRT
Transmission With
Forward, Reverse, + Neutral
See Photo -

DRAWING 17

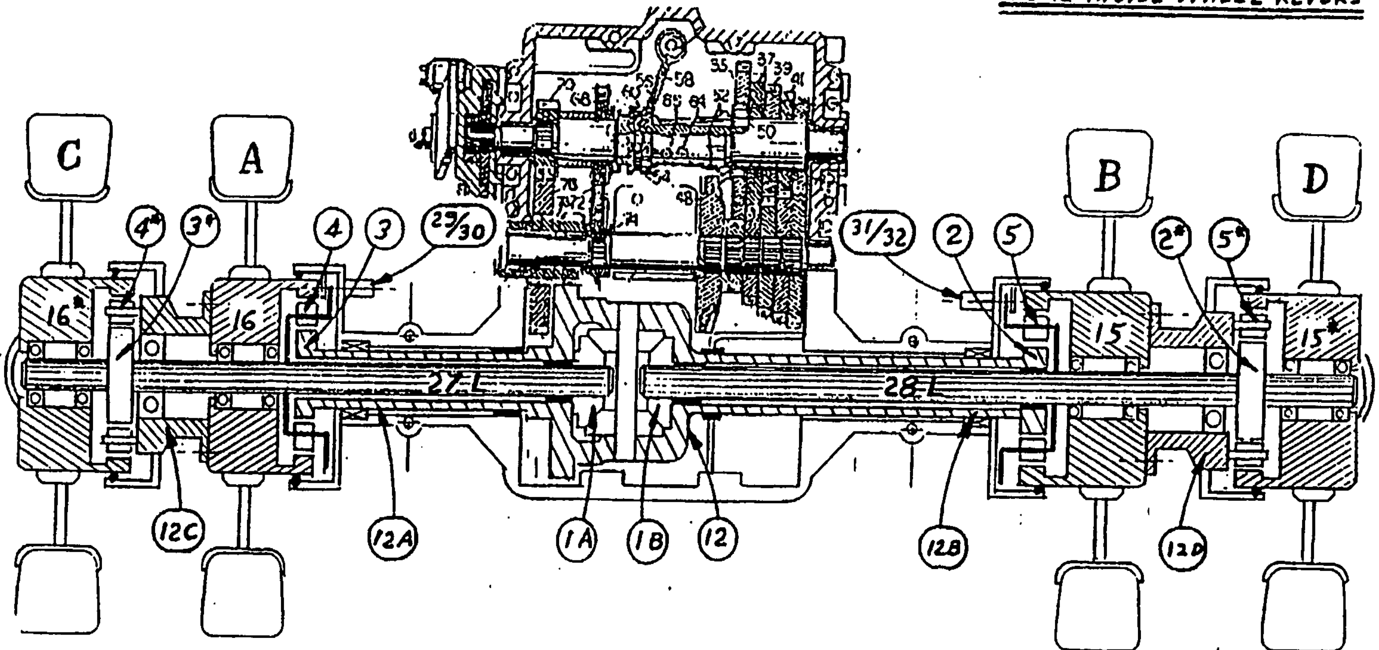
(TRANSAXLE) DRAWING 18

(TRANSAXLE) DRAWING 18



DRAWING 18

DRAWING 19
WITH
DUAL INSIDE WHEEL REVERS



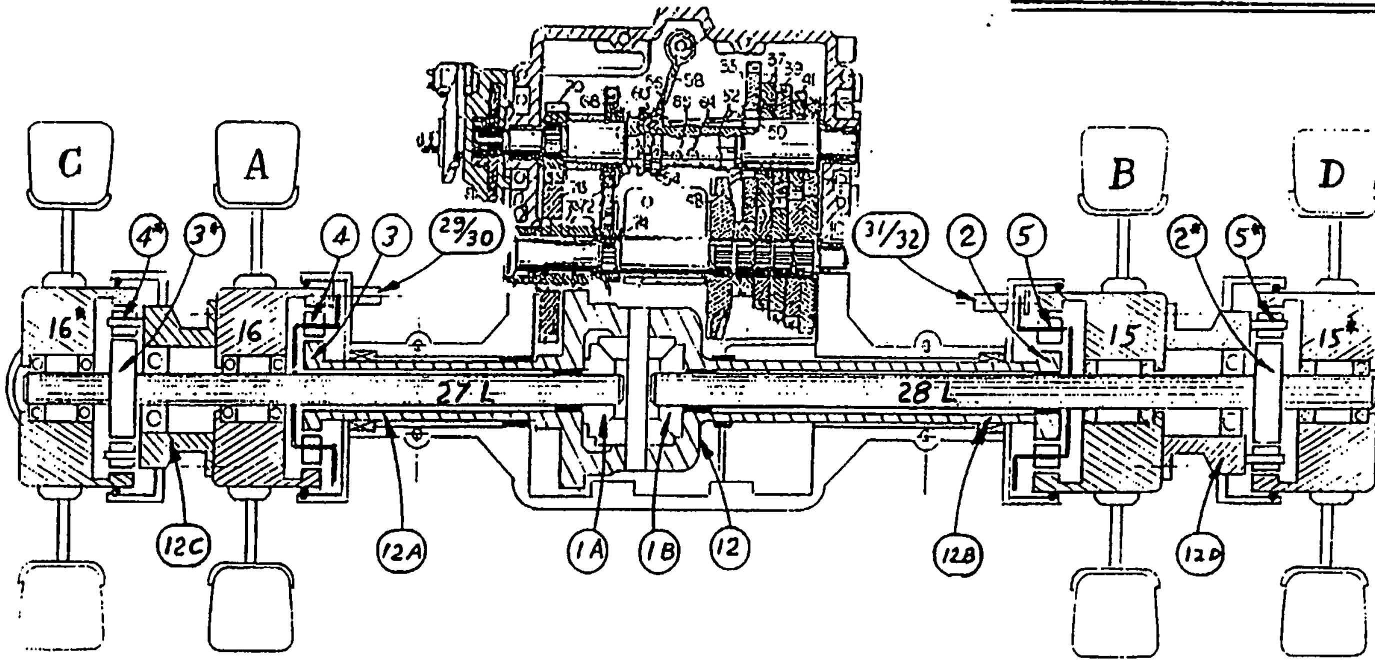
DRAWING 19

CENTER AXLE SCHEME	LEFT	RIGHT
CENTER AXLE	27L	28L
CONNECTED TO		
PLANET CLUSTER	4	5
{ BRAKES	29/30	31/32
{ SIDE BEVEL GEARS	1A	1B
{ OUTSIDE SUN GEAR	3*	2*
AND		
SUPPORTS INBOARD OUTPUT	16	15
{ OUTBOARD OUTPUT	16*	15*

TUBE AXLE SCHEME	LEFT	RIGHT
INBOARD TUBE AXLE	12A	12B
CONNECTED TO		
SUN GEARS	3	2
{ ROTATING CARRIER	12	12
OUTBOARD TUBE AXLE	12C	12D
CONNECTED TO		
ANNULAR GEARS	16	15
{ PLANETARY CLUSTER	4*	5*

DRAWING 19
WITH DUAL
INSIDE WHEEL
REVERSE

DRAWING 19
WITH
DUAL INSIDE WHEEL REVERSE



DRAWING 19-A

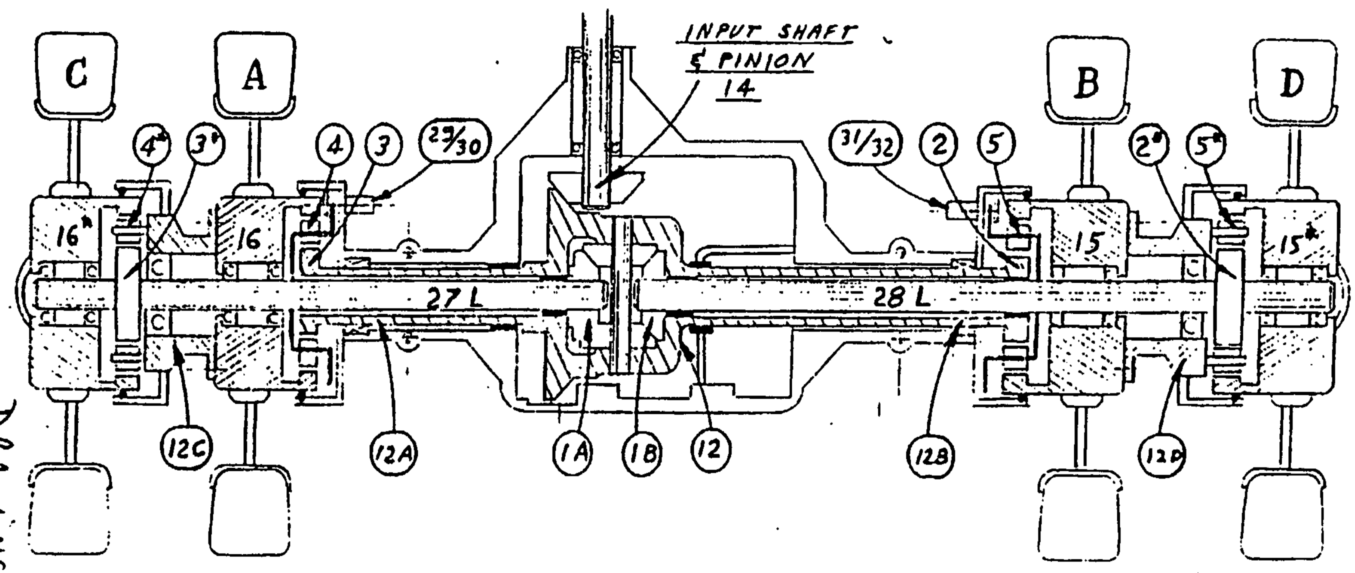
CENTER AXLE SCHEME	LEFT	RIGHT
CENTER AXLE CONNECTED TO	27L	28L
PLANET CLUSTER	4	5
{ BRAKES	29/30	31/32
{ SIDE BEVEL GEARS	1A	1B
{ OUTSIDE SUN GEAR	3*	2*
AND SUPPORTS INBOARD OUTPUT	16	15
{ OUTBOARD OUTPUT	16*	15*

TUBE AXLE SCHEME	LEFT	RIGHT
INBOARD TUBE AXLE CONNECTED TO	12A	12B
SUN GEARS	3	2
{ ROTATING CARRIER	12	12
OUTBOARD TUBE AXLE CONNECTED TO	12C	12D
ANNULAR GEARS	16	15
{ PLANETARY CLUSTER	4*	5*

DRAWING 19
WITH DUAL
INSIDE WHEEL
REVERSE

DRAWING 20

REF. DWG 1B
PLUS DUAL WHEEL ATTACHMENT

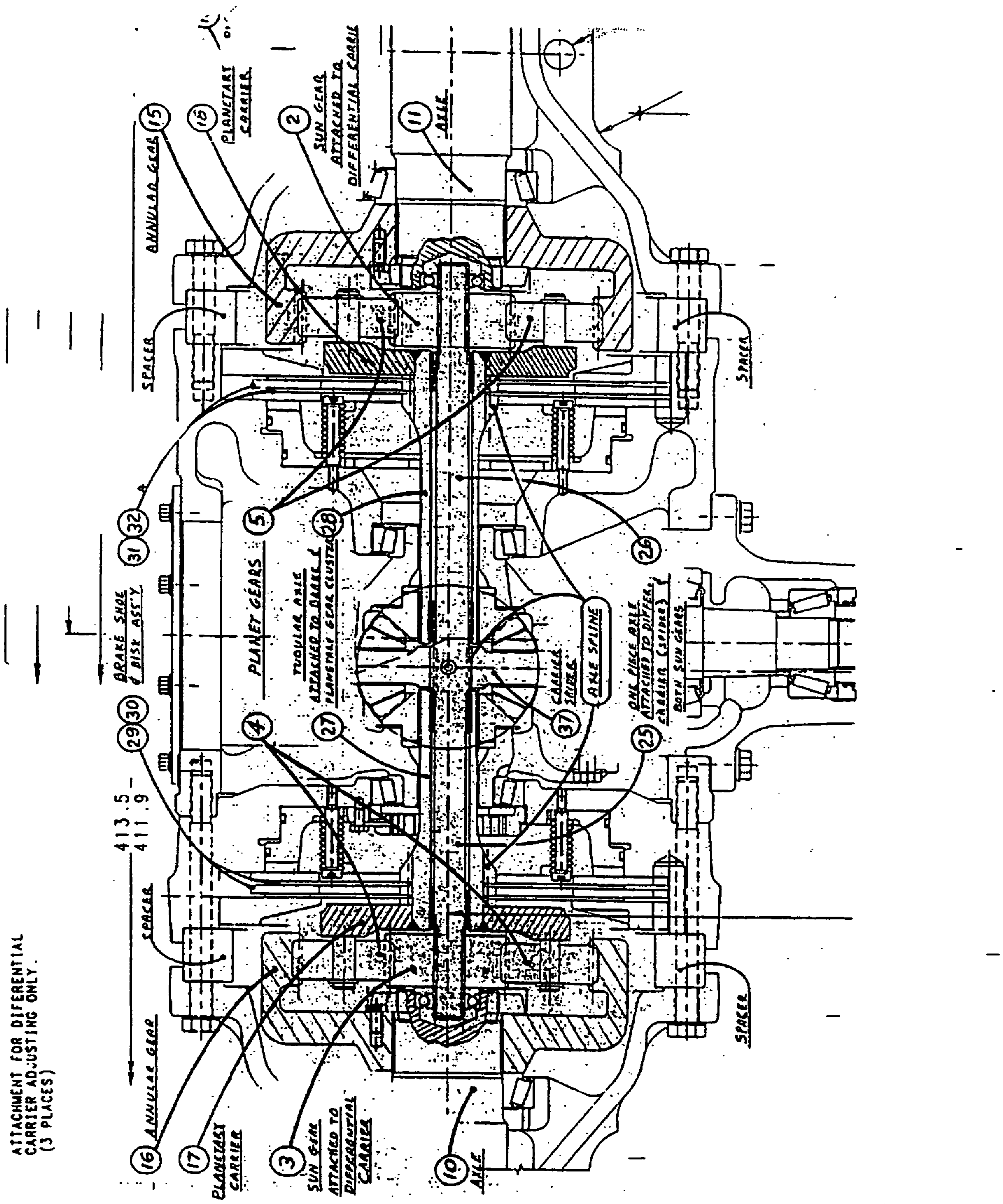


DRAWING 20

CENTER AXLE SCHEME	LEFT	RIGHT
CENTER AXLE	27L	28L
CONNECTED TO		
PLANET CLUSTER	4	5
& BRAKES	29/30	31/32
& SIDE BEVEL GEARS	1A	1B
& OUTSIDE SUN GEAR	3*	2*
AND		
SUPPORTS INBOARD OUTPUT	16	15
& OUTBOARD OUTPUT	16*	15*

TUBE AXLE SCHEME	LEFT	RIGHT
INBOARD TUBE AXLE	12A	12B
CONNECTED TO		
SUN GEARS	3	2
& ROTATING CARRIER	12	12
OUTBOARD TUBE AXLE	12C	12D
CONNECTED TO		
ANNULAR GEARS	16	15
& PLANETARY CLUSTER	4*	5*

Note: Internal Carrier



DRAWING 21

INTERNATIONAL SEARCH REPORT

Int ional Application No
PCT/US 98/20711

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B60K23/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 B60K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 546 733 A (MITSUBISHI MOTORS CORP) 16 June 1993 see claims; figures -----	1

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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